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# Evolution of Machinery Production Networks: Linkage of North America with East Asia*

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**Abstract:** This paper investigates the developing pattern of machinery trade and the extent and depth of production networks in North America from the perspective of their links with East Asia in the last two decades. Our descriptive analysis based on the total value of trade and the extensive margin demonstrates the expanding fragmentation of production in North America with a strong connection of Mexico, in addition to the US, with East Asia, particularly in the electric machinery sector. Our quantitative analysis on the total value of trade as well as extensive and intensive margins verifies the existence of such a strong connection with East Asia for machinery imports by North America, where Mexico enhanced a bridging role between East Asia and the US. These results reflect the reduction in services link costs, the further evolution of production sharing in the US-Mexico nexus, and the strengthening competitiveness for production networks in East Asia.

**Keywords**: the 2nd unbundling, fragmentation, agglomeration, free trade agreement (FTA), extensive margin

**JEL classification**: F14, F15, F23, and L23

## 1. Introduction

As a new pattern of international division of labor in terms of production processes and tasks, or so-called the 2nd unbundling (Baldwin (2011)), has been increasingly evident in the North-South and South-South trade, the evolving pattern of international production networks in the world has become an issue of great interest in both academic and non-academic literature.

The nature of transactions in international production networks or the 2nd unbundling seems to set their geographical boundaries. Unlike transactions in the traditional industry-wise international division of labor or the 1st unbundling, new types of transactions have to connect well coordinated production blocks and thus tend to be of high frequency, with high speed, and tightly synchronized. Such transactions are supposed to be sensitive to geographical distance as well as the quality of logistics links. The word "global value chains" has become popular, and a large literature on them seems to be built up quickly.[1] However, we must note that such value chains include not only the international division of labor based on the 2nd unbundling but also the traditional international division of labor in the realm of the 1st unbundling. The same caution would apply to a growing literature of value added trade in which the nature of the 2nd unbundling is not always taken care of in an explicit manner.[2] In the context of value added trade, the finding of Johnson and Noguera (2012b) on the importance of geographical proximity for production fragmentation seems to be important.

Machinery industries including general machinery, electric machinery, transport equipment, and precision machinery have continuously been forerunners in the formation of international production networks, and we have observed three notable centers of such networks in the world: East Asia including both Northeast Asia and Southeast Asia, North America, and Europe. Ando and Kimura (2013) examine the relationship of machinery production networks between East Asia and Europe, particularly focusing on the role of Central and Eastern Europe (CEE) to connect East Asia with Western Europe (WE). The study finds that in the electric machinery, East Asia starts supplying massive electronics parts and components to CEE in order to make assembly possible to serve for the WE market. This means that a part of international production networks has developed from regional to global. On the other hand, in the automobile industry, East Asia and CEE independently start forming regional industrial agglomerations. Differences in the industry characteristics clearly affect the evolving geographical pattern of international production networks.

What happens in the relationship between East Asia and North America? One common element to the East Asia–Europe relationship is the increasing dominance of East Asia as an industrial base. In East Asia, the sophistication of production fragmentation has come into a stage of forming industrial agglomerations in newly developed economies and less developed countries (LDCs), which has been led by short-distance inter-firm (arm's length) transactions. In addition, in the past decade, mild deterioration of the terms of trade due to resource price hikes vis-à-vis prices of manufactured goods pushed up the international competitiveness of East Asia for manufacturing activities. Relatively smooth labor movements from informal/rural/non-manufacturing sectors to formal/urban/manufacturing sectors helped experience relatively slow increases in labor costs compared with the rest of the developing world. The rise of China as an industrial center has been evident, but other East Asian developing countries have also presented deeper involvement in regional production networks.

Different aspects of the East Asia-North America relationship vis-à-vis East Asia-Europe include the existence of long-lasting tight links between East Asia and North America. North America has been a major external market for East Asia for several decades. Furthermore, since the 1980s, there have been active transactions of parts and components across the Pacific. Production network links between East Asia and the US are just like a turnpike overcoming geographical distance, which makes the links as tight as those extending within East Asia. The US companies have also been one of the major players for developing production networks in East Asia through trade and foreign direct investment (FDI). In addition, Mexico has occupied a special position in the trans-Pacific production networks. Mexico has worked as a site for cross-border production sharing with the US while imports of parts and components from East Asia have become considerably large, particularly in the Maquiladora operation. The formation of industrial agglomeration in Mexico, particularly in the automobile industry, is also notable in the past ten years. These may make the development of Trans-Pacific production networks between East Asia and North America somewhat different from East Asia-Europe.

The rest of the paper is organized as follows: the next section briefly discusses the underlying conceptual framework in terms of fragmentation and agglomeration to understand evolving patterns of machinery trade in North America with a link to East Asia. Section 3 then descriptively examines the developing patterns of machinery trade for North America from 1991 to 2011 from the perspective of the extent and depth of production networks in North America in connection with East Asia, based on the total value of trade and the extensive margin. Section 4 attempts to quantitatively verify the existence of such a strong connection with East Asia for machinery imports in North America and the evolution of production networks in that region, using gravity model estimations, and Section 5 concludes the paper.

## 2. Geographical Extension of International Production Networks

Machines are typically made of a large number of parts and components that are produced with using various materials and employing diversified technologies, often in remotely located production sites. Intermediate inventory storage in a machinery factory is filled with hundreds of kinds of parts and components coming from various places with different frequency and diversified transport modes of delivery. A procurement manager carefully designs and operates upstream networks, and a sale manager closely watches and controls product inventories and downstream networks. Transactions of parts and components as well as finished products in production networks can be classified into four layers in terms of the distance as in Table 1: Layer 1 (local), Layer 2 (sub-regional), Layer 3 (regional), and Layer 4 (global).[3] Layer 1 refers to transactions within industrial agglomerations, such as auto parts procurements in Bangkok Metropolitan Area or the Pearl River Delta, where a just-in-time system in the real sense can be operated with extremely squeezed intermediate inventories. Layer 2 mainly consists of transactions between neighboring industrial agglomerations, such as transactions within ASEAN or within CEE, which are still sensitive to the timeliness of deliveries in order to keep the whole production system operating. Layer 3 covers transactions extended in a whole region such as East Asia or Europe where the timeliness of deliveries in general becomes less crucial except emergency. Layer 4 denotes trans-continental transactions, which is typically conducted with ample time like two weeks to two months by ship; this is rather the 1st unbundling rather than the 2nd unbundling. Vertical upstream-downstream production networks operated by a factory consist of deliberately designed combination of these four-layer transactions, which differs by industries, products, business models, and local conditions including both location advantages for production and service link costs.

**Table 1: Four Layers of Transactions in Production Networks: Illustration**

| | Layer 1<br>(within industrial agglomeration) | Layer 2<br>(within sub-region) | Layer 3<br>(within region) | Layer 4<br>(global) |
|---|---|---|---|---|
| Lead time | Less than 2.5 hours | One to seven days | One to two weeks | Two weeks to two months |
| Frequency of transactions | Once per day or more | Once per week or more | Once a week | Once a week or less |
| Transport mode | Trucks | Trucks/ships/airplanes | Ships/airplanes | Ships/airplanes |
| Trip length | Less than 100km | 100-1,500km | 1,500-6,000km | More than 6,000km |

*Source*: Kimura (2010). Slightly modified.

Kimura and Ando (2005) propose the extension of the concept of production fragmentation to two dimensions: fragmentation in the dimension of geographical distance and fragmentation in the dimension of disintegration (intra-firm or arm's length (inter-firm)). In order to be economically viable, fragmentation in the geographical dimension requires reduction in three types of costs: (i) network set-up costs, (ii) service link costs such as transport costs in a wider sense, and (iii) production costs per se coming from location advantages such as low wages and economies of scale. Fragmentation in the disintegration dimension depends on the intimacy in the inter-firm relationship and the architecture of firm-to-firm interface. Intra-firm vs. arm's length, the strength of trust and power balance between business partners, and modular vs. total integration are coming in. Using this framework, we can list up possible determinants of layer choices of transactions as Table 2.  Arrows on the right-hand side show a rough idea of the range of layer choice affected by each element of listed determinants.

**Table 2: Determinants of The Layer Choice**

| | Layer 1 | Layer 2 | Layer 3 | Layer 4 |
|---|---|---|---|---|
| **<Fragmentation (geographical)>** | | | | |
| Network set-up costs | small ↔ | ↔ | ↔ large | |
| Service link costs (e.g., transport costs) | large ↔ | ↔ | ↔ | ↔ small |
| Location advantages (e.g., wages, economies of scale) | small ↔ | ↔ | large | |
| **<Fragmentation (disintegration)>** | | | | |
| Intimacy in inter-firm relationship | | | | |
| Intra-firm vs. arm's length (inter-firm) | Arm's length (inter-firm) ↔ | ↔ | ↔ Intra-firm | |
| Trust | weak ↔ | ↔ strong | | |
| Power balance | unbalanced ↔ | ↔ balanced | | |
| Architecture of firm-to-firm interface | | | | |
| Modular vs. total integration | integration ↔ | ↔ | ↔ modular | |

*Source*: Kimura (2010).

Table 2 is useful, for example, in interpreting differences between electronics industry and automobile industry in the geographical extension of production networks.[4] Production networks in electronics industry tend to be "sub-regional" or "regional." This is because (i) transport costs for electronic parts and components are usually low vis-à-vis the weight and the volume, (ii) economies of scale at the plant level tend to be large, (iii) trust between upstream and downstream firms is strong, particularly in cases of transactions between multinational enterprises (MNEs), (iv) power balance between upstream and downstream firms is close to being balanced, and (v) the architecture of inter-firm interface is likely to be modular. Trans-continental transactions of final products are typically slow by maritime transportation.[5]

On the other hand, production networks in the automobile industry are mostly within industrial agglomeration, i.e., "local," while some limited supplementary supplies of parts and components are "sub-regional" or "regional." This is because (i) transport costs for a large portion of the parts and components such as air ducts for air conditioners are high and thus sensitive to geographical distance, and other types of a sort of transport costs including trade barriers, non-tariff measures such as safety standards, and even local tastes make service link costs high and local production advantageous, (ii) trust between upstream and downstream firms is sometimes weak, particularly when upstream firms are small/medium enterprises or local firms, (iii) assemblers are typically much stronger than parts producers, and thus power balance is unbalanced, and (iv) the architecture of inter-firm interface is likely to be total integration.

Although these are the description of typical production networks in electronics and automobile industries, vast variations exist in the geographical pattern, depending on individual firms' strategies, location advantages, and evolution over time. For example, a local vendor network is sometimes important even in the case of electronics industry.[6] In the other extreme, semiconductors such as RAMs and system LSI are at high prices per weight and volume so that they can be transported by air, possibly traveling very long distance. Ando and Kimura (2013) finds that massive electronic parts and components began to be exported from East Asia to CEE in the past ten years; i.e., some transactions even become "global." Even final products of electronics such as Dell computers can sometimes move by air, when a client is in a hurry. In the case of automobile industry, most of the transactions are local and sub-regional in cases of East Asia though some regional transactions are required in the process of forming a critical mass of industrial agglomeration. In addition, modular or total integration reflects each company's strategies. Toyota conducts a sort of extreme total integration while Volkswagen applies a more modular approach with a limited number of car models and commonized parts and components across production sites all over the world. This difference may explain, at least partially, why tight industrial agglomeration is formed in East Asia while sub-regional transactions are large among CEE countries.

North America is a vast area, but the highway system in the US and the Southern part of Canada is superb. Therefore, considerably large areas in the US and neighboring areas can be covered as the 2nd layer transactions though the monetary cost of transportation may not be so cheap. San Diego in the US and Tijuana in Mexico are only within 15-minute drive, and thus the Southern part of California and Tijuana may work with Layer 1 transactions, particularly for electric and electronic industry. The US and inland Mexico would be covered by Layer 3 transactions. Klier *et al.* (2004; particularly Map 1) present the geographical distribution of auto supplier plants over the areas starting from Detroit, coming down to the South, and then going into the inland Mexico. East Asia and North America are supposed to be connected mainly with Layer 4 transactions though some limited air connection may almost work as Layer 3 transactions.

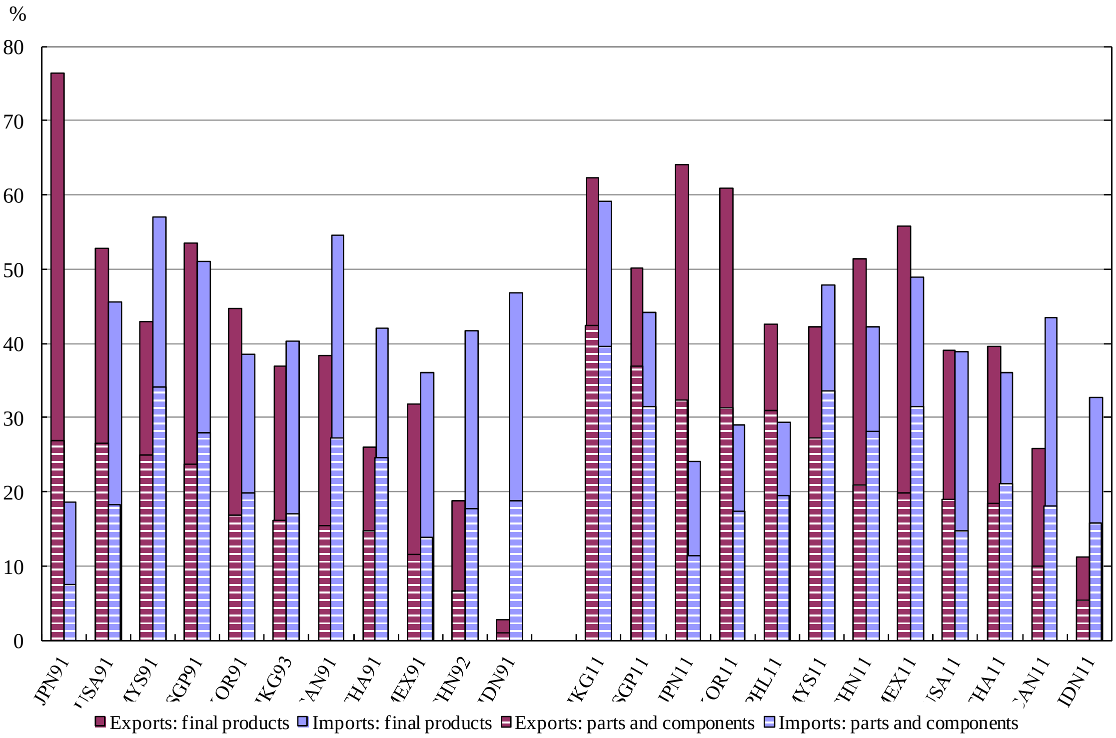
## 3. Evolution of Machinery Trade in North America

This section descriptively analyzes the developing patterns of machinery trade for three North American countries from 1991 to 2011 from the perspective of production networks in North America and their links with East Asia.

### 3.1. Features Based on The Trade Value

Figure 1 presents the ratios of machinery goods in total exports to and imports from the world in two regions in around 1991 and 2011. The figures array countries in terms of the export share of machinery parts and components. The portion of machinery parts and components is shown with stripes.[7] The export ratios of machinery parts and components are in particular good indicators to judge how far the country concerned participates in international production networks in machinery industries. All East Asian countries/economies in the figure increased the export ratios of machinery parts and components between 1991 and 2011, which indicates deepening involvements in production networks. The US was already a major exporter of machinery parts and components in 1991, though the export ratios a little declined in 2011. Canada seems to become a relatively less important player in international production networks. Mexico, on the contrary, came into production networks during the period.

**Figure 1: Machinery Goods and Machinery Parts and Components for North America and East Asia: Shares in Total Exports and Imports in 1991 and 2011**




*Note*: data for China and Hong Kong in 1991 are not available, and thus data in 1992 and 1993 are used, respectively. Data for the Philippines in the first half of the 1990s is not available.

*Data source*: authors' calculation, using data available from UN comtrade.

To demonstrate the pattern of geographical extension of production networks, the following examines disaggregated trade data by destination/origin. Table 3 presents trade values to the world, value indices by major origins/destinations, i.e., the world, East Asia, North American countries, and shares of each origin/destination in total trade (trade to the word) for all machinery imports and exports of three North American countries in 1991 and 2011 (HS84 to 92).[8] Considering the different nature of sectors even among machinery sectors, Tables 4 and 5 show the corresponding figures in the electric machinery sector (HS85) and transport equipment sector (HS86 to 89).

**Table 3: By-origin/destimation Value and Share of Machinery Trade in North America: All Machinery Sectors**

| | Year | Ori./ Dest. | i) Imports Total | i) Imports Parts | i) Imports Final | ii) Exports Total | ii) Exports Parts | ii) Exports Final |
|---|---|---|---|---|---|---|---|---|
| **(a) USA** | | | | | | | | |
| Value | 1991 | World | 232,170 | 93,082 | 139,088 | 222,278 | 111,626 | 110,653 |
| (millions US$) | 2011 | World | 881,143 | 334,084 | 547,059 | 577,691 | 279,718 | 297,973 |
| Value index | 2011 | World | 3.8 | 3.6 | 3.9 | 2.6 | 2.5 | 2.7 |
| (1991=1) | 2011 | E Asia | 3.7 | 3.7 | 3.7 | 2.6 | 2.7 | 2.5 |
| | 2011 | MEX | 9.4 | 6.5 | 12.5 | 5.1 | 5.0 | 5.4 |
| | 2011 | CAN | 2.1 | 1.9 | 2.2 | 2.6 | 2.0 | 3.3 |
| Share | 1991 | E.Asia | 47.7 | 41.3 | 52.0 | 20.6 | 21.3 | 19.9 |
| (in total (%)) | 1991 | MEX | 6.9 | 8.9 | 5.5 | 7.7 | 10.6 | 4.8 |
| | 1991 | CAN | 17.9 | 16.9 | 18.6 | 22.3 | 24.5 | 20.1 |
| | 2011 | E.Asia | 46.8 | 43.0 | 49.2 | 20.6 | 23.1 | 18.2 |
| | 2011 | MEX | 17.0 | 16.1 | 17.6 | 15.1 | 21.0 | 9.6 |
| | 2011 | CAN | 9.9 | 9.2 | 10.3 | 22.2 | 19.9 | 24.4 |
| **(b) Mexico** | | | | | | | | |
| Value | 1991 | World | 13,750 | 5,276 | 8,474 | 8,561 | 3,128 | 5,432 |
| (millions US$) | 2011 | World | 171,373 | 110,219 | 61,154 | 195,044 | 69,218 | 125,825 |
| Value index | 2011 | World | 12.5 | 20.9 | 7.2 | 22.8 | 22.1 | 23.2 |
| (1991=1) | 2011 | E.Asia | 55.9 | 129.8 | 26.9 | 59.3 | 59.4 | 59.2 |
| | 2011 | USA | 7.6 | 12.4 | 4.4 | 23.8 | 26.5 | 22.4 |
| | 2011 | CAN | 17.0 | 23.7 | 12.4 | 18.2 | 15.5 | 19.9 |
| Share | 1991 | E.Asia | 9.5 | 7.0 | 11.1 | 0.7 | 0.7 | 0.7 |
| (in total (%)) | 1991 | USA | 61.4 | 64.0 | 59.7 | 79.4 | 73.1 | 83.0 |
| | 1991 | CAN | 1.6 | 1.7 | 1.5 | 4.6 | 4.9 | 4.4 |
| | 2011 | E.Asia | 42.6 | 43.3 | 41.2 | 1.7 | 1.8 | 1.7 |
| | 2011 | USA | 37.3 | 37.9 | 36.3 | 82.8 | 87.6 | 80.2 |
| | 2011 | CAN | 2.1 | 1.9 | 2.6 | 3.6 | 3.4 | 3.8 |
| **(c) Canada** | | | | | | | | |
| Value | 1991 | World | 64,454 | 32,177 | 32,276 | 48,648 | 19,514 | 29,134 |
| (millions US$) | 2011 | World | 195,427 | 81,634 | 113,794 | 116,269 | 44,584 | 71,684 |
| Value index | 2011 | World | 3.0 | 2.5 | 3.5 | 2.4 | 2.3 | 2.5 |
| (1991=1) | 2011 | E.Asia | 4.4 | 5.2 | 4.1 | 5.0 | 4.1 | 6.4 |
| | 2011 | USA | 2.3 | 1.9 | 2.7 | 2.2 | 2.0 | 2.2 |
| | 2011 | MEX | 9.8 | 6.4 | 13.3 | 12.7 | 11.9 | 14.9 |
| Share | 1991 | E.Asia | 15.5 | 9.2 | 21.7 | 2.0 | 3.0 | 1.3 |
| (in total (%)) | 1991 | USA | 68.1 | 73.9 | 62.2 | 88.2 | 84.0 | 91.1 |
| | 1991 | MEX | 2.8 | 2.9 | 2.7 | 0.3 | 0.6 | 0.2 |
| | 2011 | E.Asia | 22.6 | 18.9 | 25.3 | 4.2 | 5.4 | 3.5 |
| | 2011 | USA | 51.6 | 56.5 | 48.0 | 79.6 | 74.4 | 82.9 |
| | 2011 | MEX | 9.1 | 7.4 | 10.4 | 1.8 | 3.1 | 0.9 |

*Data source*: authors' calculation, using data available from Uncomtrade.

**Table 4: By-origin/destination Value and Share of Machinery Trade in North America: Electric Machinery Sector**

| | Year | Ori./ Dest. | i) Imports Total | i) Imports Parts | i) Imports Final | ii) Exports Total | ii) Exports Parts | ii) Exports Final |
|---|---|---|---|---|---|---|---|---|
| **(a) USA** | | | | | | | | |
| Value | 1991 | World | 62,392 | 33,004 | 29,388 | 49,139 | 33,758 | 15,382 |
| (millions US$) | 2011 | World | 281,640 | 109,777 | 171,863 | 157,755 | 97,622 | 60,133 |
| Value index | 2011 | World | 4.5 | 3.3 | 5.8 | 3.2 | 2.9 | 3.9 |
| (1991=1) | 2011 | E Asia | 4.3 | 3.1 | 5.3 | 3.3 | 3.3 | 3.3 |
| | 2011 | MEX | 6.6 | 4.2 | 10.2 | 5.0 | 4.2 | 8.2 |
| | 2011 | CAN | 1.7 | 1.1 | 3.4 | 2.6 | 1.8 | 4.3 |
| Share | 1991 | E.Asia | 60.7 | 52.4 | 70.1 | 28.2 | 30.8 | 22.4 |
| (in total (%)) | 1991 | MEX | 13.2 | 14.9 | 11.4 | 12.9 | 15.0 | 8.3 |
| | 1991 | CAN | 8.0 | 11.7 | 3.9 | 21.3 | 21.9 | 19.8 |
| | 2011 | E.Asia | 57.7 | 49.5 | 63.0 | 29.0 | 35.1 | 19.0 |
| | 2011 | MEX | 19.5 | 18.8 | 19.9 | 20.1 | 21.8 | 17.3 |
| | 2011 | CAN | 2.9 | 3.9 | 2.3 | 16.9 | 14.0 | 21.6 |
| **(b) Mexico** | | | | | | | | |
| Value | 1991 | World | 3,861 | 1,784 | 2,077 | 868 | 475 | 393 |
| (millions US$) | 2011 | World | 75,224 | 53,101 | 22,123 | 70,923 | 29,095 | 41,827 |
| Value index | 2011 | World | 19.5 | 29.8 | 10.7 | 81.7 | 61.3 | 106.4 |
| (1991=1) | 2011 | E.Asia | 72.5 | 179.7 | 28.5 | 147.9 | 109.1 | 212.9 |
| | 2011 | USA | 9.6 | 13.7 | 6.2 | 86.6 | 67.0 | 111.2 |
| | 2011 | CAN | 11.2 | 11.8 | 10.4 | 121.1 | 81.1 | 137.8 |
| Share | 1991 | E.Asia | 15.0 | 9.5 | 19.8 | 0.9 | 1.1 | 0.8 |
| (in total (%)) | 1991 | USA | 55.4 | 55.3 | 55.5 | 80.3 | 81.6 | 78.9 |
| | 1991 | CAN | 1.7 | 2.0 | 1.4 | 2.5 | 1.4 | 3.9 |
| | 2011 | E.Asia | 55.9 | 57.1 | 53.0 | 1.7 | 1.9 | 1.5 |
| | 2011 | USA | 27.4 | 25.4 | 32.3 | 85.2 | 89.2 | 82.4 |
| | 2011 | CAN | 1.0 | 0.8 | 1.4 | 3.8 | 1.8 | 5.1 |
| **(c) Canada** | | | | | | | | |
| Value | 1991 | World | 13,580 | 8,460 | 5,119 | 6,445 | 4,847 | 1,598 |
| (millions US$) | 2011 | World | 45,381 | 19,915 | 25,465 | 15,344 | 7,653 | 7,692 |
| Value index | 2011 | World | 3.3 | 2.4 | 5.0 | 2.4 | 1.6 | 4.8 |
| (1991=1) | 2011 | E.Asia | 6.4 | 6.3 | 6.4 | 3.8 | 2.6 | 7.2 |
| | 2011 | USA | 1.8 | 1.5 | 2.4 | 2.0 | 1.3 | 4.4 |
| | 2011 | MEX | 19.6 | 9.9 | 36.1 | 32.7 | 30.1 | 48.6 |
| Share | 1991 | E.Asia | 20.5 | 11.2 | 35.7 | 4.6 | 4.6 | 4.8 |
| (in total (%)) | 1991 | USA | 59.3 | 64.5 | 50.8 | 81.4 | 82.5 | 78.1 |
| | 1991 | MEX | 2.5 | 2.6 | 2.5 | 0.4 | 0.4 | 0.2 |
| | 2011 | E.Asia | 39.0 | 30.2 | 46.0 | 7.4 | 7.6 | 7.1 |
| | 2011 | USA | 31.8 | 41.8 | 24.0 | 68.4 | 65.5 | 71.3 |
| | 2011 | MEX | 14.9 | 10.8 | 18.0 | 5.3 | 8.3 | 2.2 |

*Data source*: authors' calculation, using data available from Uncomtrade.

**Table 5: By-origin/destination Value and Share of Machinery Trade in North America: Transport Equipment Sector**

| | Year | Ori./ Dest. | i) Imports Total | i) Imports Parts | i) Imports Final | ii) Exports Total | ii) Exports Parts | ii) Exports Final |
|---|---|---|---|---|---|---|---|---|
| **(a) USA** | | | | | | | | |
| Value | 1991 | World | 83,192 | 20,081 | 63,111 | 72,339 | 25,949 | 46,390 |
| (millions US$) | 2011 | World | 230,783 | 65,910 | 164,873 | 132,793 | 47,087 | 85,706 |
| Value index | 2011 | World | 2.8 | 3.3 | 2.6 | 1.8 | 1.8 | 1.8 |
| (1991=1) | 2011 | E Asia | 2.1 | 3.4 | 1.7 | 1.2 | 1.1 | 1.2 |
| | 2011 | MEX | 10.8 | 9.8 | 11.3 | 4.2 | 4.0 | 4.6 |
| | 2011 | CAN | 2.0 | 1.7 | 2.0 | 2.5 | 1.8 | 3.0 |
| Share | 1991 | E.Asia | 39.8 | 34.2 | 41.6 | 16.0 | 13.2 | 17.6 |
| (in total (%)) | 1991 | MEX | 5.2 | 7.5 | 4.5 | 6.3 | 13.3 | 2.3 |
| | 1991 | CAN | 34.3 | 31.4 | 35.2 | 27.4 | 36.1 | 22.5 |
| | 2011 | E.Asia | 29.7 | 35.2 | 27.6 | 10.1 | 8.2 | 11.2 |
| | 2011 | MEX | 20.3 | 22.3 | 19.5 | 14.2 | 29.7 | 5.7 |
| | 2011 | CAN | 24.2 | 16.6 | 27.3 | 36.6 | 36.5 | 36.6 |
| **(b) Mexico** | | | | | | | | |
| Value | 1991 | World | 1,824 | 640 | 1,184 | 4,627 | 528 | 4,099 |
| (millions US$) | 2011 | World | 30,102 | 18,880 | 11,222 | 65,063 | 17,664 | 47,399 |
| Value index | 2011 | World | 16.5 | 29.5 | 9.5 | 14.1 | 33.4 | 11.6 |
| (1991=1) | 2011 | E.Asia | 65.5 | 145.5 | 35.2 | 141.6 | 398.6 | 123.4 |
| | 2011 | USA | 14.3 | 26.6 | 7.2 | 12.1 | 33.8 | 9.3 |
| | 2011 | CAN | 42.6 | 62.5 | 31.9 | 20.1 | 347.8 | 14.3 |
| Share | 1991 | E.Asia | 4.8 | 3.8 | 5.4 | 0.2 | 0.1 | 0.2 |
| (in total (%)) | 1991 | USA | 65.3 | 68.2 | 63.7 | 87.3 | 87.4 | 87.3 |
| | 1991 | CAN | 2.2 | 2.2 | 2.2 | 3.2 | 0.5 | 3.6 |
| | 2011 | E.Asia | 19.2 | 18.7 | 20.1 | 2.1 | 1.4 | 2.3 |
| | 2011 | USA | 56.5 | 61.6 | 48.0 | 75.3 | 88.5 | 70.4 |
| | 2011 | CAN | 5.7 | 4.6 | 7.4 | 4.6 | 5.1 | 4.4 |
| **(c) Canada** | | | | | | | | |
| Value | 1991 | World | 26,293 | 10,710 | 15,583 | 30,735 | 7,206 | 23,529 |
| (millions US$) | 2011 | World | 72,450 | 24,223 | 48,227 | 63,407 | 13,339 | 50,069 |
| Value index | 2011 | World | 2.8 | 2.3 | 3.1 | 2.1 | 1.9 | 2.1 |
| (1991=1) | 2011 | E.Asia | 2.3 | 4.2 | 1.8 | 7.4 | 4.6 | 10.0 |
| | 2011 | USA | 2.5 | 1.9 | 3.0 | 1.9 | 1.7 | 2.0 |
| | 2011 | MEX | 6.4 | 4.0 | 8.1 | 9.3 | 6.7 | 18.2 |
| Share | 1991 | E.Asia | 15.1 | 7.1 | 20.6 | 0.6 | 1.1 | 0.4 |
| (in total (%)) | 1991 | USA | 71.7 | 82.3 | 64.4 | 93.9 | 89.7 | 95.2 |
| | 1991 | MEX | 4.1 | 4.2 | 4.0 | 0.3 | 0.9 | 0.1 |
| | 2011 | E.Asia | 12.4 | 13.3 | 12.0 | 2.0 | 2.8 | 1.8 |
| | 2011 | USA | 65.1 | 69.2 | 63.1 | 88.5 | 84.5 | 89.6 |
| | 2011 | MEX | 9.5 | 7.4 | 10.5 | 1.2 | 3.2 | 0.7 |

*Data source*: authors' calculation, using data available from Uncomtrade.

The tables provide several interesting insights. First of all, both machinery imports and exports by North America have drastically expanded during the last 20 years, and the production sharing in this region has significantly developed particularly in the US-Mexico nexus. As the value index for the world in Table 3 indicates, all machinery imports and exports grew by three to four times and around 2.5 times in these 20 years, respectively, for the US and Canada, and by 13 times and 23 times for Mexico. In addition, imports of machinery parts and components increased by 21 times, and exports of machinery parts and components as well as final products by 22 to 23 times for Mexico (Table 3 (b)). Moreover, the share of Mexico in the US machinery trade was significantly enlarged, particularly imports of final products (from six to 18 percent) and exports of parts and components (from 11 to 21 percent), while the share of Canada in the US imports declined (Table 3 (a)). The share of Mexico also increased for the Canada's machinery trade from three percent to nine percent, but the majority of Canada's trade is still with the US (Table 3 (c)). These evidences suggest that the US has continuously played an central role for machinery trade in North America, and that the expansion of production sharing in North America has been observed mainly in the US-Mexico nexus during the last two decades; the US exports parts and components to Mexico, and Mexico exports final products to the US, using intermediate goods imported from the US.

Second, more interestingly, production networks are not completed within the region particularly in the electric machinery sector. In this sector, the portion of East Asia reached close to 60 percent of the imports by the US and Mexico and 40 percent by Canada in 2011 (Table 4).[9] Although the share of East Asia slightly declined in the US from 61 to 58 percent (70 to 63 percent) for the total (final products only), the import value *per se* grew by four times (five times). For Mexico, imports from East Asia, particularly in machinery parts and components, notably increased: 180 times for parts and components and 29 times for final products (Table 4 (b)). As a result, the import share of East Asia expanded from less than 10 to 57 percent for parts and components and from 20 to 53 percent for final products, while the share of the US declined. Similarly to Mexico, Canada increased in the share of East Asia for both parts and components and final products, while it decreased in the share of the US (Table 4 (c)). These suggest that the production networks in this sector obviously extended beyond the region, with imports of key parts and components as well as finished machinery products from East Asia, particularly from the perspective of the production sharing in the US-Mexico nexus. As Table A.1 in the Appendix clearly shows, many East Asian countries are ranked in the top 20 origins of imports for all three countries in 2011. The dominance of Japan in 1991 was replaced by a rise of China by 2011. The rankings of other East Asian countries including Korea, Malaysia, and possibly Taiwan notably went up in the electric machinery sector.

Note that East Asia occupies over the one-third of the U.S. exports in electric machinery parts and components; the value expanded by three times and the share grew from 31 to 35 percent (Table 4 (a)). Combined with the fact that imports in electric machinery final products from East Asia significantly increased by five times from 21 to 108 billions US$, though the share slightly declined from 70 to 63 percent, the large and increasing share of East Asia in exports of parts and components and the expanding imports of final products from East Asia would suggest the US firms' operations behind the strengthening link between the US and East Asia (transactions between US affiliates in East Asia and US parent firms), in addition to the East Asian firms' operations in the US and Mexico (transactions between East Asian affiliates in the US and Mexico and their parent firms and affiliates in East Asia).

Third, in contrast with the electric machinery sector, the intra-regional share is basically higher for both exports and imports in the transport equipment sector, though the share of imports from East Asia increased in parts and components even in this sector for all three countries: from 34 to 35 percent for the US, from four to 19 percent for Mexico, and from seven to 13 percent for Canada (Table 5). The top four origins of imports are the other two North American countries, Japan, and Germany in 2011 for all three North American countries (Table A.1 (i)). If we focus on only parts and components, however, the corresponding origins are Canada/the US, Mexico, Japan, and China for the US and Canada, and the US, Japan, Germany, and China for Mexico (Table A.1 (ii)). Moreover, the portion of Mexico significantly increased for the US imports in parts and components of this sector from eight to 22 percent (Table 5 (a)). These emphasize that production networks expanded from regional to more global with a connection with East Asia on the import side even in the transport equipment sector, but not so extensively as in the electric machinery sector. Industrial clustering and locating firms of supporting industries nearby and close to customers must be more important in the transport equipment sector.

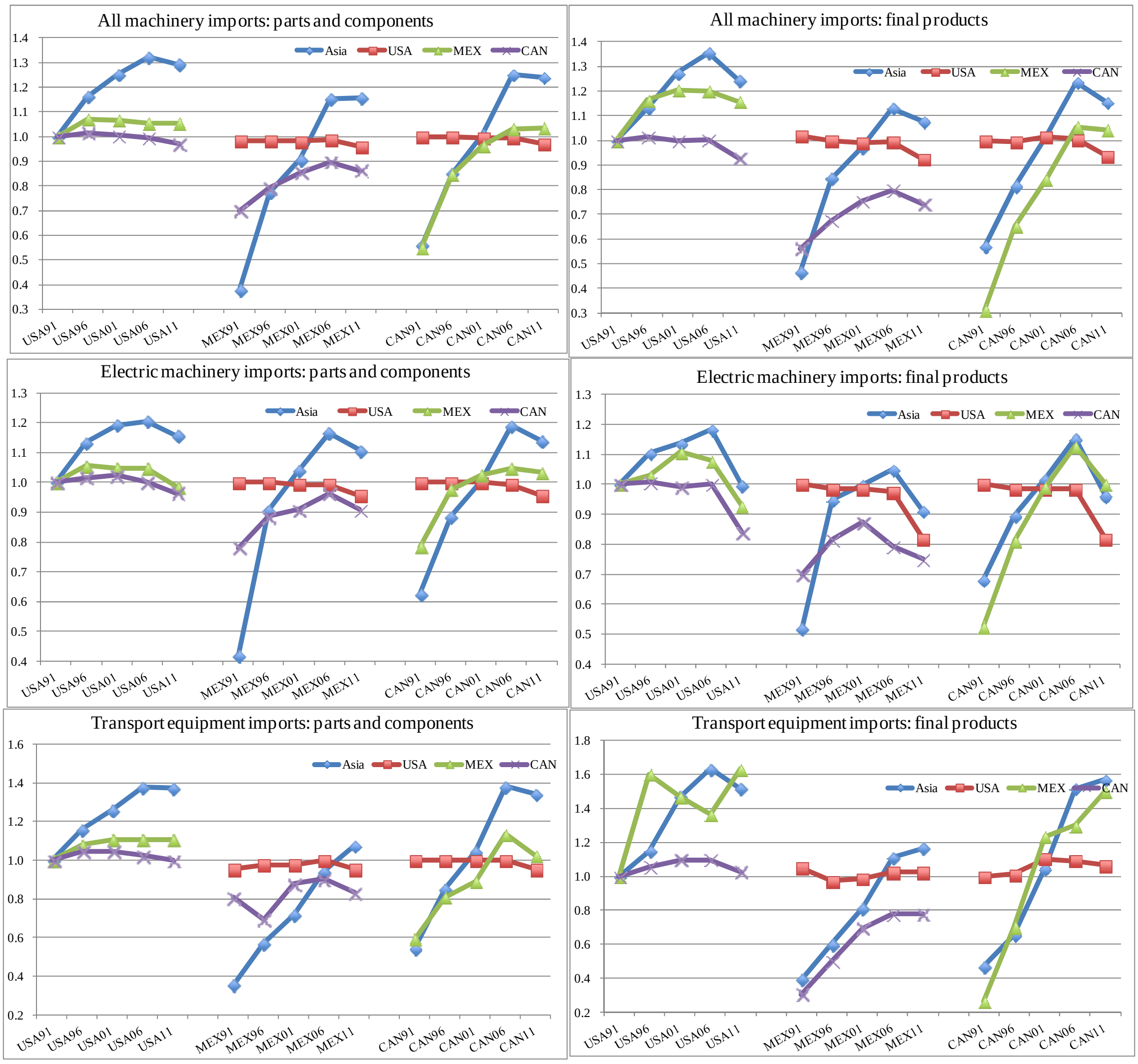
Fourth, a significant amount of transactions between Mexico and East Asia is through the US. Due to the lack of deep sea ports in Mexico (particularly near the US-Mexico border where many firms operate cross-border production sharing) and logistics reasons, Mexico's exports to East Asia and imports from East Asia go through the Long Beach near Los Angeles in the US. Generally speaking, statistics of exports are based on the first destination, and those of imports are based on the origin. Therefore, Mexico's export data may overestimate to some extent the importance of the US as the final destination of exports, and East Asia's export data may underestimate to some extent its exports to Mexico. Figure A.1. in the Appendix demonstrates this possibility. Of course, import data (cost, insurance and freight: c.i.f.) and export data (free on board: f.o.b) are not exactly the same because imports data include transportation fee and insurance etc, but Mexico's imports from East Asia and East Asia's exports to Mexico are apparently and significantly different since the 2000s; Mexico's imports from East Asia are about twice as large as East Asia's exports to Mexico. This suggests that a significant portion of Mexico's imports from East Asia (i.e., East Asia's exports to Mexico) comes through the US. Similarly, Mexico's exports to East Asia and East Asia's imports from Mexico are different; although Mexico's exports to East Asia *per se* are much smaller than Mexico's imports from East Asia, they are about a half of East Asia's imports from Mexico. It indicates that a certain portion of Mexico's exports to the US is not for the US but for other countries including East Asia.

### 3.2. Features Based on The Extensive Margin

To further investigate changes in trade patterns or the extent and depth of production networks, this subsection focuses on the extensive margin, that is, the number of traded products times the number of trading partners. Figure 2 demonstrates the number of imported product-country pairs by four origins in 1991, 1996, 2001, 2006, and 2011 in all machinery sectors, electric machinery sector, and transport equipment sector, and Figure 3 presents the corresponding number of exported product-country pairs by four destinations.[10] The number for each origin/destination is indexed to the number of the US in 1991 for three origins (destinations) i.e., Mexico, Canada, East Asia, and the number of Canada in 1991 for the US as an origin (destination). The index smaller than one indicates that the country has been less involved in production networks, compared with the situation of the US (or Canada) in 1991, and the increasing number of index suggests that the country has been more deeply involved in fragmentation of production than before. On the other hand, Tables 6 (7) present the percentage of varieties traded with each country of North America (East Asia) among those traded with the world by individual North American country in 1991, 2001, and 2011. 100 percent implies that all varieties that are traded by a concerned country with any country in the world are traded with that country.

**Figure 2: The Number of Product-country Pairs for Imports by North America**

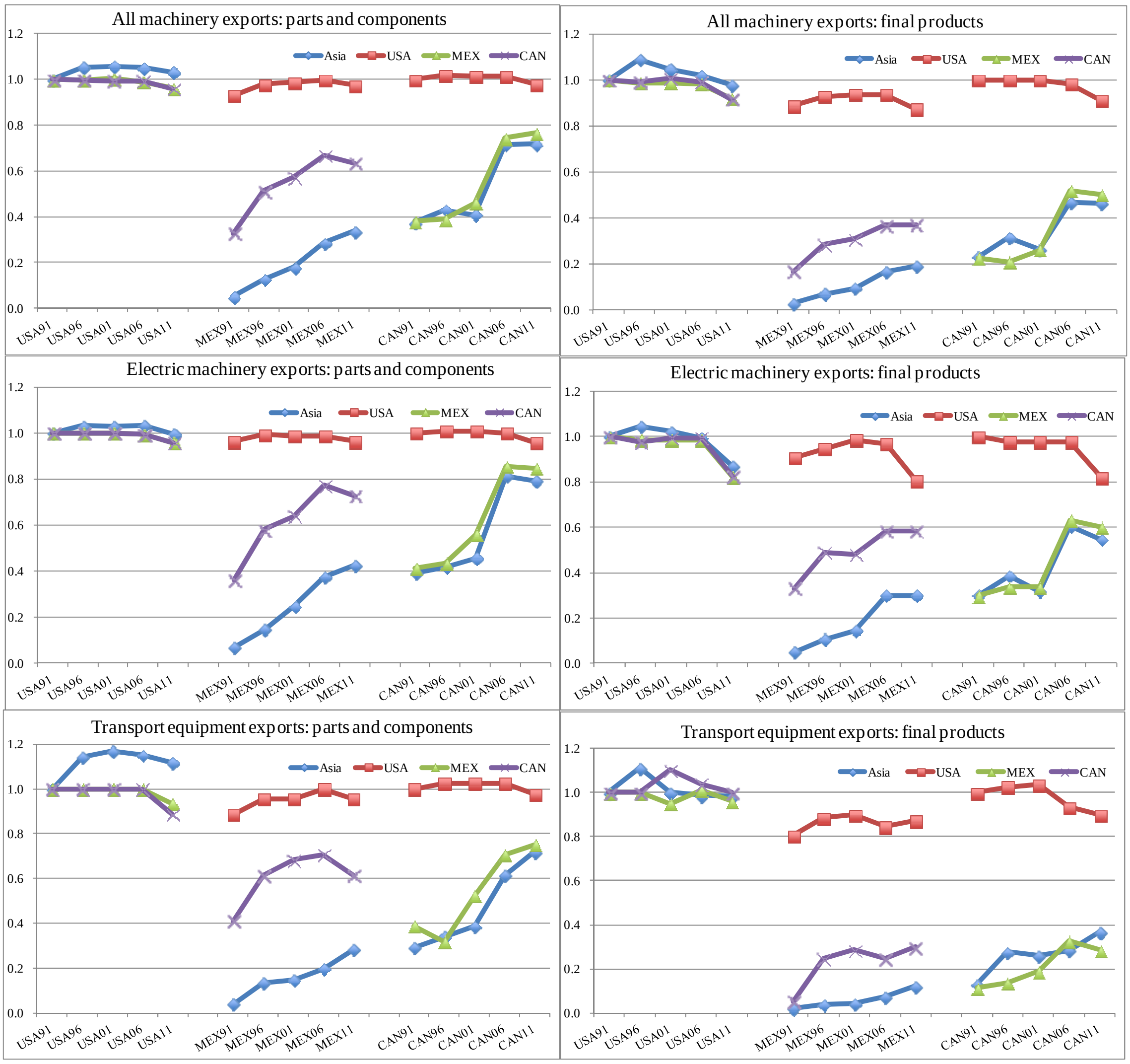
(USA in 1991 = 1 for Asia, MEX, CAN; Canada in 1991 for USA)




*Data source*: authors' calculation, using data available from UN comtrade.

**Figure 3: The Number of Product-country Pairs for Exports by North America**

(USA in 1991 = 1 for Asia, MEX, CAN; Canada in 1991 for USA)




*Data source*: authors' calculation, using data available from UN comtrade.

**Table 6: The Share of Varieties Traded with Each North American Country among Those Traded with The World by Each Country (%)**

| | Ori./ Dest. | USA | | | Mexico | | | Canada | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 1991 | 2001 | 2011 | 1991 | 2001 | 2011 | 1991 | 2001 | 2011 |
| **i) Imports** | | | | | | | | | | |
| All machinery sectors | USA | | | | 99 | 99 | 99 | 99 | 99 | 100 |
| | MEX | 67 | 77 | 80 | | | | 29 | 61 | 74 |
| | CAN | 93 | 94 | 94 | 57 | 75 | 78 | | | |
| Electric machinery sector | USA | | | | 100 | 100 | 100 | 100 | 100 | 100 |
| | MEX | 85 | 92 | 92 | | | | 57 | 87 | 97 |
| | CAN | 95 | 97 | 97 | 71 | 86 | 89 | | | |
| Transport equipment sector | USA | | | | 98 | 98 | 98 | 99 | 99 | 98 |
| | MEX | 52 | 66 | 73 | | | | 24 | 53 | 65 |
| | CAN | 89 | 96 | 94 | 44 | 71 | 73 | | | |
| **ii) Exports** | | | | | | | | | | |
| All machinery sectors | USA | | | | 93 | 96 | 96 | 99 | 99 | 98 |
| | MEX | 99 | 99 | 99 | | | | 29 | 34 | 65 |
| | CAN | 98 | 99 | 98 | 24 | 42 | 51 | | | |
| Electric machinery sector | USA | | | | 95 | 98 | 99 | 99 | 99 | 99 |
| | MEX | 100 | 100 | 100 | | | | 36 | 45 | 82 |
| | CAN | 100 | 100 | 100 | 35 | 56 | 74 | | | |
| Transport equipment sector | USA | | | | 89 | 97 | 94 | 98 | 97 | 94 |
| | MEX | 95 | 92 | 94 | | | | 21 | 29 | 47 |
| | CAN | 93 | 99 | 92 | 19 | 45 | 43 | | | |

*Data source*: authors' calculation, using data available from UNcomtrade.

**Table 7: The Share of Varieties Traded with Each East Asian Country among Those Traded with The World by Each Country (%)**

| | i) Imports | | | | | | | | | ii) Exports | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | USA | | | Mexico | | | Canada | | | USA | | | Mexico | | | Canada | | |
| Ori./ Dest. | 1991 | 2001 | 2011 | 1991 | 2001 | 2011 | 1991 | 2001 | 2011 | 1991 | 2001 | 2011 | 1991 | 2001 | 2011 | 1991 | 2001 | 2011 |
| All machinery sectors | | | | | | | | | | | | | | | | | | |
| CHN | 64 | 86 | 94 | 22 | 72 | 93 | 30 | 79 | 95 | 74 | 90 | 94 | 0 | 15 | 39 | 20 | 37 | 69 |
| HKG | 59 | 60 | 61 | 31 | 36 | 43 | 40 | 52 | 58 | 87 | 89 | 88 | 4 | 11 | 24 | 30 | 35 | 52 |
| IDN | 11 | 35 | 39 | 4 | 25 | 38 | 2 | 22 | 39 | 64 | 64 | 74 | 1 | 4 | 11 | 12 | 12 | 40 |
| JPN | 93 | 92 | 90 | 75 | 84 | 84 | 76 | 86 | 88 | 95 | 96 | 92 | 17 | 29 | 35 | 43 | 42 | 57 |
| KOR | 64 | 78 | 81 | 17 | 61 | 71 | 41 | 62 | 75 | 91 | 92 | 92 | 1 | 11 | 28 | 28 | 28 | 51 |
| MYS | 29 | 49 | 54 | 6 | 36 | 47 | 11 | 34 | 49 | 70 | 80 | 80 | 1 | 7 | 17 | 18 | 19 | 44 |
| PHL | 22 | 35 | 39 | 3 | 22 | 31 | 7 | 22 | 36 | 75 | 79 | 76 | 1 | 4 | 10 | 14 | 15 | 35 |
| SGP | 46 | 54 | 55 | 14 | 33 | 43 | 20 | 35 | 42 | 87 | 91 | 89 | 4 | 10 | 20 | 30 | 29 | 52 |
| THA | 31 | 47 | 56 | 5 | 32 | 51 | 10 | 34 | 55 | 76 | 79 | 83 | 0 | 6 | 16 | 19 | 19 | 43 |
| Electric machinery sector | | | | | | | | | | | | | | | | | | |
| CHN | 83 | 97 | 100 | 34 | 89 | 99 | 49 | 95 | 100 | 81 | 95 | 98 | 0 | 27 | 61 | 29 | 46 | 87 |
| HKG | 83 | 82 | 86 | 52 | 62 | 70 | 62 | 74 | 79 | 97 | 97 | 97 | 7 | 18 | 48 | 44 | 48 | 74 |
| IDN | 22 | 60 | 64 | 6 | 55 | 63 | 5 | 43 | 62 | 74 | 73 | 85 | 2 | 4 | 18 | 11 | 13 | 59 |
| JPN | 99 | 99 | 98 | 93 | 96 | 97 | 92 | 98 | 98 | 99 | 99 | 98 | 27 | 40 | 48 | 52 | 52 | 75 |
| KOR | 84 | 92 | 94 | 36 | 78 | 86 | 70 | 82 | 92 | 96 | 98 | 97 | 1 | 19 | 49 | 42 | 40 | 71 |
| MYS | 61 | 76 | 80 | 16 | 68 | 78 | 31 | 64 | 80 | 81 | 90 | 93 | 2 | 12 | 29 | 19 | 30 | 63 |
| PHL | 40 | 61 | 64 | 8 | 52 | 57 | 19 | 44 | 64 | 91 | 90 | 88 | 0 | 9 | 19 | 18 | 22 | 46 |
| SGP | 79 | 76 | 77 | 30 | 64 | 68 | 46 | 60 | 67 | 97 | 99 | 98 | 8 | 19 | 35 | 43 | 39 | 75 |
| THA | 54 | 69 | 74 | 8 | 59 | 76 | 19 | 56 | 78 | 88 | 90 | 91 | 1 | 11 | 25 | 23 | 27 | 62 |
| Transport equipment sector | | | | | | | | | | | | | | | | | | |
| CHN | 43 | 65 | 71 | 15 | 41 | 69 | 13 | 53 | 76 | 59 | 75 | 81 | 0 | 9 | 25 | 10 | 27 | 54 |
| HKG | 27 | 35 | 35 | 14 | 13 | 16 | 14 | 21 | 37 | 64 | 72 | 67 | 1 | 4 | 9 | 14 | 21 | 39 |
| IDN | 10 | 20 | 27 | 8 | 18 | 23 | 4 | 19 | 26 | 45 | 50 | 56 | 0 | 3 | 6 | 7 | 9 | 25 |
| JPN | 73 | 71 | 69 | 47 | 51 | 55 | 54 | 60 | 70 | 85 | 88 | 79 | 14 | 19 | 27 | 35 | 37 | 45 |
| KOR | 42 | 57 | 53 | 3 | 32 | 42 | 29 | 38 | 52 | 81 | 82 | 81 | 0 | 8 | 22 | 13 | 21 | 34 |
| MYS | 7 | 25 | 25 | 1 | 14 | 22 | 2 | 18 | 26 | 54 | 60 | 59 | 0 | 4 | 6 | 10 | 15 | 36 |
| PHL | 15 | 19 | 24 | 1 | 6 | 12 | 2 | 14 | 21 | 65 | 63 | 60 | 1 | 0 | 7 | 4 | 12 | 26 |
| SGP | 17 | 23 | 32 | 4 | 8 | 20 | 10 | 16 | 23 | 75 | 75 | 77 | 2 | 3 | 8 | 21 | 22 | 38 |
| THA | 20 | 27 | 43 | 2 | 18 | 31 | 9 | 21 | 37 | 58 | 60 | 66 | 0 | 6 | 13 | 6 | 18 | 26 |

*Data source*: authors' calculation, using data available from UNcomtrade.

The figures and tables provide four interesting findings. First, the US continuously plays a central role of the North American trade, and the expansion of North American trade, particularly that of Mexican/Canadian trade with the US, is mostly due to an expansion of intensive margin (the value per traded product), rather than that of extensive margin (the number of traded products). Almost all varieties that are traded by Mexico/Canada with any country in the world are traded at least with the US (Table 6). Moreover, the index representing the number of commodities imported from or exported to the US by Mexico/Canada remains more or less stable since 1991, except a decline in 2011 (Figure 2), which suggests that the North American trade expanded mostly due to an expansion of the intensive margin. Although the relative importance of the US as an origin slightly declined, probably because the expansion of the intensive margin of imports was not so sufficiently large compared with imports from countries outside of the region, their imports from the US *per se* still significantly expanded.

Second, the connection between Canada and Mexico became stronger than before, probably due to the North American Free Trade Agreement (NAFTA), which entered into force on January 1994, particularly from the perspective of parts and components, but not so strong as a link between the US and Mexico. The number of commodities imported from Canada by the US (or the number of commodities exported to the US by Canada) remained more or less stable since 1991 for both parts and components and final products (Figure 2 (3)). On the other hand, the number for imports from Canada by Mexico and that for imports from Mexico by Canada basically tend to increase for both parts and components and final products, probably due to NAFTA; the number for these imports expanded more rapidly for parts and components.[11] We have to note that, however, the number for imports from Canada by Mexico is still much smaller than that for imports from Canada by the US in 1991 particularly for machinery final products (less than 80 percent) (Figure 2). The number of exported varieties also confirms this; the number for exports to Canada by Mexico and that for exports to Mexico by Canada are still around 70 percent and 40 to 50 percent of the number for exports to the US at the beginning of the 1990s for parts and components and final products, respectively, though the corresponding numbers tend to increase for both (Figure 3). In other words, the connection between Canada and Mexico became stronger than before from the perspective of parts and components, probably due to NAFTA, but not so strong as a link between the US and Mexico.

Third, all three countries, particularly Mexico and Canada, dramatically increased the number of machinery product-country pairs for imports from East Asia.[12] In the case of electric machinery parts and components, in particular, Mexico rapidly expanded the variety from much lower level at the beginning of the 1990s (around 40 percent) to the almost same level of the US by 2011 (Figure 2). As Table 7 shows, the percentage of the variety in terms of traded commodities by Mexico in a concerning year rapidly increased for many East Asian countries in the electric machinery sector; for instance from 34 to 99 percent for China, from 93 percent in 1991 to 97 percent in 2011 for Japan, from 36 percent to 86 percent for Korea, 16 to 78 percent for Malaysia, and from eight to 76 percent for Thailand. Combined with the fact that the connection between the US and Mexico is getting stronger as mentioned above, all of these evidences indicate that transactions of Mexico with East Asia become much more active with a greater variety of product-country pairs and that the extent and depth of fragmentation of production in the US-Mexico nexus enhanced with a connection of East Asia particularly in the electric machinery sector. On the export side, the value *per se* is much smaller than the value of imports (Table 4). Moreover, the extensive margin is still much lower than the level of the US for Mexico, though the number tends to increase, which suggests the growing connection with East Asia in terms of the variety (Figure 3).

Fourth, the connection between North America and East Asia seems to be stronger in the electric machinery sector than the transport equipment sector. The extensive margin is much lower, which indicate the smaller number of traded varieties, for the transport equipment sector than the electric machinery sector in general (Table 7). It can be interpreted as a plausible result, probably reflecting the nature of the sector; the transport equipment sector requires industrial clusters nearby as well as higher transport costs, while parts and components in the electric machinery sector, for instance, are in general smaller and lighter and thus are relatively easy to be transported to countries in a longer distance.

## 4. Machinery Imports of North America from Asia: Gravity Model Estimations

The previous section descriptively demonstrated the expanding fragmentation of production in North America with a strong connection of Mexico, in addition to the US, with East Asia on the import side, based on the value of trade and the extensive margin. This section quantitatively verifies the existence of such a strong connection with East Asia for machinery imports in North America and the evolution of production networks from regional to the Trans-Pacific, using gravity model estimations. The gravity models are estimated for trade in all machinery sectors, trade in the electric machinery sector, and trade in the transport equipment sector, with a distinction between machinery parts and components and final products. Moreover, the paper investigates such patterns not only for the total value of trade but also for the extensive margin (the number of traded product) and the intensive margin (trade value per product) separately. Although exports to East Asia expanded particularly in terms of the extensive margin, they are still much smaller than imports, and thus this section focuses on a connection of North America, mainly Mexico, with East Asia on the import side.

### 4.1. Estimation Methodology and Data

The basic equation of our gravity model estimations for bilateral machinery imports of three North American countries is as follows:

$$lnT_{ij} = \alpha + \beta_1 lnDist_{ij} + \beta_2 lnGDP_i + \beta_3 lnGDP_j + \beta_4 lnGDPpc_{ij(i>j)} + \beta_5 lnGDPpc_{ij(i<j)} + \varepsilon, \quad (1)$$

where $T_{ij}$ denotes the total value of bilateral imports of country $i$ from country $j$, $Dist_{ij}$ geographical distance between capitals of country $i$ and country $j$, $GDP_i$ ($GDP_i$) gross domestic products (GDP) of country $i$ ($j$), and $GDPpc_{ij}$ the absolute term of the difference in GDP per capita between country $i$ and country $j$. Note that $GDPpc_{ij(i>j)}$ is for the cases of country $i$ with higher GDP per capita than that of country $j$, and $GDPpc_{ij(i<j)}$ is for the cases of country $i$ with lower GDP per capita than that of country $j$.[13] Distance is regarded as a transport cost or services link cost, and the coefficient is supposed to be negative. GDP is a proxy of the market size, and the coefficient is supposed to be positive. The difference in GDP per capita between two countries can be interpreted as a measure of (the absolute term of) differences in factor endowments. The coefficient will be positive if the difference in factor endowments is one of the important determinants for the pattern of international division of labor in terms of production processes or tasks as the fragmentation theory suggests. However, now that

fragmentation of production becomes "networks" and trade at the production-process level is active even between developing countries, the difference in factor endowments may not sufficiently capture the overall trade pattern at the aggregated level.

Since we are interested in possible changes in the effects of transport cost or services link cost as well as the features of imports from East Asia, additional three types of equations are also examined as follows:

$$lnT_{ij} = \alpha + \beta_{1USA} lnDist_{ij} USA + \beta_{1MEX} lnDist_{ij} MEX + \beta_{1CAN} lnDist_{ij} CAN + \beta_2 lnGDP_i + \beta_3 lnGDP_j + \beta_4 lnGDPpc_{ij(i>j)} + \beta_5 lnGDPpc_{ij(i<j)} + \varepsilon \ , \quad (2)$$

$$lnT_{ij} = \alpha + \beta_1 lnDist_{ij} + \beta_2 lnGDP_i + \beta_3 lnGDP_j + \beta_4 lnGDPpc_{ij(i>j)} + \beta_5 lnGDPpc_{ij(i<j)} + + \beta_6 E.Asia + \varepsilon, \quad (3)$$

$$lnT_{ij} = \alpha + \beta_1 lnDist_{ij} + \beta_2 lnGDP_i + \beta_3 lnGDP_j + \beta_4 lnGDPpc_{ij(i>j)} + \beta_5 lnGDPpc_{ij(i<j)} + \beta_{6USA} E.AsiaUSA + \beta_{6MEX} E.AsiaMEX + \beta_{6CAN} E.AsiaCAN + \varepsilon, \quad (4)$$

where $USA$, $MEX$, and $CAN$ are dummy variables with one for the US, Mexico, and Canada, respectively, and zero for others. Similarly, $E.Asia$ is a dummy variable with one for nine East Asian countries and zero for others. In equations (2) and (4), interaction terms of three North American dummy variables with distance or East Asian dummy are included. As for East Asian dummy, the coefficient would be positive if imports from East Asia are greater than the levels predicted by the model, considering distance and other basic economic conditions. Regarding interaction terms of East Asian dummy with each North American country dummy, the coefficient of that with Mexico would be (become) positive and be greater than other interaction terms if a connection of Mexico with East Asia becomes stronger.

Moreover, as the total value of trade can be rewritten as the trade value per product multiplied by the number of traded product, the total value of trade can be decomposed into the extensive margin (the number of traded product) and the intensive margin (trade value per product) by taking the form of logarithm. Thus, equation (1), for instance, can be decomposed into the following two equations:

$$lnN_{ij} = \alpha + \beta_1 lnDist_{ij} + \beta_2 lnGDP_i + \beta_3 lnGDP_j + \beta_4 lnGDPpc_{ij(i>j)} + \beta_5 lnGDPpc_{ij(i<j)} + \varepsilon, \quad (1')$$

$$ln(T_{ij}/N_{ij}) = \alpha + \beta_1 lnDist_{ij} + \beta_2 lnGDP_i + \beta_3 lnGDP_j + \beta_4 lnGDPpc_{ij(i>j)} + \beta_5 lnGDPpc_{ij(i<j)} + \varepsilon, \quad (1'')$$

where $N_{ij}$ is the number of imported products (extensive margin) and $T_{ij}/N_{ij}$ is the import value per product (intensive margin). This paper regards the number of imported products at the HS 6-digit level as the measure of the extensive margin, namely the number of commodities at the HS 6-digit level with positive import values, and the total values of imports divided by the number of imported products as the measure of intensive margin.[14]

Based on the above-mentioned equations, we investigate the link of North America with East Asia in both years, 1991 and 2011, for imports in all machinery sectors, those in the electric sector, and those in the transport equipment sector, with a distinction between machinery parts and components and final products. By comparing the results, we would like to capture the features of machinery imports by North American countries, particularly those from East Asia and see whether any significant changes between 1991 and 2011 exist between different machinery sectors, between extensive and intensive margins, and between parts and components and final products.

Table A.2 in the Appendix lists 60 countries in the sample: countries are restricted to those with more than 0.01 percent of machinery imports from the world in 2011 by at least one North American country as well as necessary data such as GDP and GDP per capita for both years. The data on trade values in US dollars are obtained from UN comtrade[15], geographical distance are from CEPII database[16], and GDP and GDP per capita are from the World Development Indicators online[17]. The number of products imported from each country is counted as the number of commodities with positive import values at the HS1992 six-digit level, and the import value per product is obtained by dividing the total value of imports by the number of imported products.

There exist zeros in our bilateral trade matrix. A drop of observations with zero trade cannot utilize potentially useful information and may cause sample selection bias. As suggested in the previous section, the extensive margin significantly expanded from 1991 to 2011, particularly for the Mexican imports. For a comparison of the results in 1991 with those in 2011, it is important to include observations with zero trade, particularly for the estimations on the extensive margin. Considering that the treatment of zero-valued trade is regarded as a major issue in the literature, the above-mentioned gravity equations are estimated with the pseudo Poisson maximum likelihood (PPML) method, which is proposed by Silva and Tenreyro (2006).[18] PPML technique enables us to estimate gravity models, including observations with zero trade, without taking the form of logarithm for dependent variable (that is, the dependent variable is the actual value). Note that equations (1’) and (1”) with the actual value of dependent variable do not mean the exact decomposition of equation (1) any more with PPML technique

### 4.2. The Estimation Results

Tables 8 and 9 show the results for the total imports in parts and components and final products, respectively, in all machinery sectors, the electric machinery sector, and the transport equipment sector. Tables 10 and 11, on the other hand, present the corresponding results for the extensive and intensive margins; only the cases with East Asian dummy is displayed here. The major findings are as follows: first, the services link cost may be reduced, and/or the export competitiveness of East Asia with a longer distance from North America may be strengthened, particularly in the electric machinery sector (Tables 8 and 9). The coefficient for distance in the absolute term becomes smaller when the results for 1991 are compared with those for 2011, except the case with East Asia dummy for electric final products (equations c-8/11 and d-8/11 in Table 9). Moreover, the coefficient for distance for electric machinery parts and components became insignificant any more in 2011 as the results for equations a-2 and a-5 in Table 8 show. These indicate a possible reduction in services link cost such as the transport cost, which accelerates the international fragmentation of production even beyond the region, particularly for the electric machinery parts and components, and the strengthened competitiveness of East Asia in this sector.

**Table 8: Gravity Model Estimations for Machinery Imports of North America: Parts and Components**

| a) PPML | 1991 | | | 2011 | | |
|---|---|---|---|---|---|---|
| | All | Elec | Trans | All | Elec | Trans |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Dist | -0.89 *** | -0.84 *** | -1.27 *** | -0.41 ** | -0.22 | -0.77 ** |
| | (0.08) | (0.19) | (0.10) | (0.21) | (0.32) | (0.30) |
| GDPi | 1.21 *** | 1.23 *** | 1.46 *** | 0.73 *** | 0.50 *** | 0.93 *** |
| | (0.10) | (0.17) | (0.15) | (0.12) | (0.17) | (0.11) |
| GDPj | 1.12 *** | 0.98 *** | 1.41 *** | 1.10 *** | 0.86 *** | 1.32 *** |
| | (0.10) | (0.15) | (0.11) | (0.11) | (0.16) | (0.17) |
| GDPpcij | 0.18 | 0.44 * | 0.23 | 0.04 | 0.10 | 0.15 |
| (i>j) | (0.13) | (0.23) | (0.17) | (0.16) | (0.20) | (0.28) |
| GDPpcij | 0.25 ** | 0.52 ** | 0.30 * | 0.05 | 0.08 | 0.18 |
| (i<j) | (0.12) | (0.22) | (0.16) | (0.15) | (0.20) | (0.25) |
| Cons. | -37.96 | -38.44 *** | -52.17 *** | -26.64 *** | -16.50 ** | -38.53 *** |
| | (5.24) | (8.55) | (6.48) | (4.84) | (7.47) | (5.80) |
| R2 | 0.944 | 0.771 | 0.976 | 0.715 | 0.451 | 0.727 |
| Pseudo LL | -3.66E+10 | -2.72E+10 | -4.85E+09 | -2.34E+11 | -1.63E+11 | -3.77E+10 |

| c) PPML (East Asia dummy) | 1991 | | | 2011 | | |
|---|---|---|---|---|---|---|
| | All | Elec | Trans | All | Elec | Trans |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Dist | -1.13 *** | -1.37 *** | -1.39 *** | -0.86 *** | -1.05 *** | -0.99 *** |
| | (0.10) | (0.21) | (0.06) | (0.18) | (0.24) | (0.25) |
| GDPi | 0.96 *** | 0.98 *** | 1.14 *** | 0.68 *** | 0.48 *** | 0.85 *** |
| | (0.09) | (0.15) | (0.12) | (0.10) | (0.14) | (0.12) |
| GDPj | 0.96 *** | 0.70 *** | 1.29 *** | 0.87 *** | 0.57 *** | 1.17 *** |
| | (0.11) | (0.17) | (0.08) | (0.11) | (0.13) | (0.15) |
| GDPpcij | 0.05 | 0.29 | 0.13 | 0.09 | 0.16 | 0.18 |
| (i>j) | (0.16) | (0.31) | (0.16) | (0.14) | (0.18) | (0.26) |
| GDPpcij | 0.06 | 0.28 | 0.13 | 0.11 | 0.17 | 0.21 |
| (i<j) | (0.15) | (0.36) | (0.16) | (0.13) | (0.18) | (0.23) |
| E.Asia | 1.51 *** | 2.32 *** | 1.27 *** | 1.43 *** | 2.29 *** | 0.83 ** |
| | (0.33) | (0.51) | (0.29) | (0.30) | (0.39) | (0.34) |
| Cons. | -23.63 *** | -18.42 ** | -37.79 *** | -15.69 *** | -1.90 | -30.64 *** |
| | (5.87) | (10.02) | (5.56) | (4.76) | (5.91) | (5.93) |
| R2 | 0.943 | 0.787 | 0.986 | 0.738 | 0.517 | 0.718 |
| Pseudo LL | -2.56E+10 | -1.64E+10 | -3.75E+09 | -1.77E+11 | -1.10E+11 | -3.44E+10 |

| b) PPML (distance* each North American dummy) | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Dist*USA | -0.87 *** | -0.71 ** | -1.43 *** | -0.79 ** | -0.73 | -1.14 ** |
| | (0.14) | (0.34) | (0.07) | (0.33) | (0.51) | (0.52) |
| Dist*MEX | -0.90 *** | -1.11 *** | -0.86 *** | -0.42 *** | -0.39 * | -0.59 *** |
| | (0.12) | (0.20) | (0.13) | (0.13) | (0.23) | (0.20) |
| Dist*CAN | -0.81 *** | -0.94 *** | -0.77 *** | -0.67 *** | -0.72 *** | -0.82 *** |
| | (0.09) | (0.15) | (0.11) | (0.17) | (0.25) | (0.31) |
| GDPi | 1.31 * | 0.28 | 3.55 *** | 1.61 | 1.14 | 2.44 ** |
| | (0.73) | (1.49) | (0.42) | (1.06) | (1.81) | (1.24) |
| GDPj | 1.14 *** | 0.97 *** | 1.58 *** | 1.09 *** | 0.86 *** | 1.35 *** |
| | (0.13) | (0.18) | (0.11) | (0.10) | (0.13) | (0.13) |
| GDPpcij | 0.25 * | 0.50 * | 0.43 *** | 0.07 | 0.21 | 0.17 |
| (i>j) | (0.15) | (0.27) | (0.16) | (0.16) | (0.20) | (0.29) |
| GDPpcij | 0.31 ** | 0.57 ** | 0.50 *** | -0.02 | 0.06 | 0.10 |
| (i<j) | (0.14) | (0.27) | (0.14) | (0.12) | (0.16) | (0.21) |
| Cons. | -42.05 * | -11.70 | -118.55 *** | -49.88 | -32.33 | -82.22 ** |
| | (23.96) | (46.44) | (14.16) | (31.29) | (53.31) | (34.44) |
| R2 | 0.948 | 0.779 | 0.987 | 0.763 | 0.580 | 0.752 |
| Pseudo LL | -3.53E+10 | -2.62E+10 | -3.50E+09 | -1.97E+11 | -1.32E+11 | -3.39E+10 |

| d) PPML (East Asia dummy * each North American dummy) | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Dist | -1.11 *** | -1.33 *** | -1.39 *** | -0.91 *** | -1.17 *** | -0.99 *** |
| | (0.08) | (0.18) | (0.06) | (0.19) | (0.26) | (0.26) |
| GDPi | 0.83 *** | 0.75 *** | 1.13 *** | 0.70 *** | 0.54 ** | 0.84 *** |
| | (0.12) | (0.23) | (0.16) | (0.17) | (0.26) | (0.17) |
| GDPj | 0.95 *** | 0.68 *** | 1.29 *** | 0.87 *** | 0.57 *** | 1.16 *** |
| | (0.11) | (0.17) | (0.09) | (0.11) | (0.12) | (0.13) |
| GDPpcij | 0.05 | 0.25 | 0.14 | 0.12 | 0.25 | 0.18 |
| (i>j) | (0.16) | (0.38) | (0.17) | (0.14) | (0.18) | (0.27) |
| GDPpcij | 0.04 | 0.26 | 0.14 | 0.12 | 0.22 | 0.21 |
| (i<j) | (0.15) | (0.38) | (0.16) | (0.13) | (0.17) | (0.24) |
| E.Asia*USA | 1.74 *** | 2.61 *** | 1.28 *** | 1.39 *** | 2.20 *** | 0.85 * |
| | (0.40) | (0.64) | (0.36) | (0.36) | (0.47) | (0.49) |
| E.Asia*MEX | -0.44 * | 0.12 | -1.15 *** | 2.19 *** | 3.41 *** | 1.05 ** |
| | (0.25) | (0.32) | (0.30) | (0.60) | (0.85) | (0.52) |
| E.Asia*CAN | 1.01 *** | 1.32 *** | 1.56 *** | 0.56 * | 1.02 ** | 0.56 |
| | (0.19) | (0.30) | (0.22) | (0.31) | (0.50) | (0.40) |
| Cons. | -19.43 *** | -11.09 | -37.46 *** | -16.26 *** | -3.45 | -30.18 *** |
| | (6.74) | (12.56) | (6.94) | (5.69) | (8.01) | (6.32) |
| R2 | 0.952 | 0.812 | 0.987 | 0.748 | 0.563 | 0.716 |
| Pseudo LL | -2.37E+10 | -1.50E+10 | -3.53E+09 | -1.60E+11 | -9.46E+10 | -3.41E+10 |

*Notes*: figures in parenthesis ares tandard deviation. *** indicates that the results are statistically significant at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level.

*Data*: authors' calculation.

## Table 9: Gravity Model Estimations for Machinery Imports of North America: Final Products

**a) PPML**

| | 1991 | | | 2011 | | |
|---|---|---|---|---|---|---|
| | All | Elec | Trans | All | Elec | Trans |
| | (7) | (8) | (9) | (10) | (11) | (12) |
| Dist | -0.78 *** | -0.34 | -1.25 *** | -0.58 ** | -0.40 | -0.94 *** |
| | (0.16) | (0.30) | (0.19) | (0.26) | (0.56) | (0.27) |
| GDPi | 1.34 *** | 1.25 *** | 1.91 *** | 1.10 *** | 0.95 *** | 1.19 *** |
| | (0.14) | (0.16) | (0.27) | (0.14) | (0.22) | (0.18) |
| GDPj | 1.12 *** | 1.11 *** | 1.37 *** | 1.26 *** | 1.35 *** | 1.09 *** |
| | (0.11) | (0.15) | (0.13) | (0.14) | (0.15) | (0.18) |
| GDPpcij | 0.15 | 0.63 *** | -0.02 | 0.21 | 0.70 ** | -0.16 |
| (i>j) | (0.12) | (0.22) | (0.19) | (0.19) | (0.30) | (0.25) |
| GDPpcij | 0.26 ** | 0.70 *** | 0.12 | 0.19 | 0.61 ** | -0.19 |
| (i<j) | (0.12) | (0.22) | (0.18) | (0.17) | (0.29) | (0.22) |
| Cons. | -42.44 *** | -48.65 *** | -61.55 *** | -41.97 *** | -47.85 *** | -35.89 *** |
| | (5.84) | (7.83) | (9.53) | (6.86) | (7.27) | (8.48) |
| R2 | 0.921 | 0.817 | 0.935 | 0.719 | 0.782 | 0.725 |
| Pseudo LL | -6.44E+10 | -2.41E+10 | -2.09E+10 | -3.19E+11 | -1.39E+11 | -1.15E+11 |

**b) PPML (distance* reporter dummy)**

| | (7) | (8) | (9) | (10) | (11) | (12) |
|---|---|---|---|---|---|---|
| Dist*USA | -0.93 *** | 0.03 | -1.58 *** | -0.93 ** | -1.00 | -1.36 *** |
| | (0.18) | (0.81) | (0.11) | (0.41) | (0.74) | (0.46) |
| Dist*MEX | -0.43 *** | -0.82 *** | -0.07 | -0.18 | 0.04 | -0.35 |
| | (0.13) | (0.24) | (0.14) | (0.13) | (0.20) | (0.22) |
| Dist*CAN | -0.45 *** | -0.50 *** | -0.21 * | -0.36 * | -0.30 | -0.57 ** |
| | (0.09) | (0.13) | (0.09) | (0.19) | (0.24) | (0.27) |
| GDPi | 2.95 *** | -1.03 | 6.44 *** | 3.43 *** | 4.05 | 4.29 *** |
| | (0.90) | (3.20) | (0.55) | (1.22) | (2.57) | (1.38) |
| GDPj | 1.19 *** | 1.10 *** | 1.64 *** | 1.34 *** | 1.44 *** | 1.21 *** |
| | (0.14) | (0.18) | (0.13) | (0.14) | (0.18) | (0.17) |
| GDPpcij | 0.23 * | 0.74 ** | 0.08 | 0.23 | 0.78 *** | -0.17 |
| (i>j) | (0.14) | (0.29) | (0.21) | (0.19) | (0.25) | (0.25) |
| GDPpcij | 0.34 ** | 0.81 *** | 0.24 | 0.15 | 0.56 *** | -0.29 |
| (i<j) | (0.13) | (0.30) | (0.19) | (0.14) | (0.20) | (0.20) |
| Cons. | -90.80 *** | 14.31 | -200.15 *** | -112.11 *** | -139.65 * | -128.21 *** |
| | (28.14) | (91.88) | (17.25) | (35.50) | (76.14) | (38.83) |
| R2 | 0.946 | 0.837 | 0.986 | 0.746 | 0.815 | 0.752 |
| Pseudo LL | -6.12E+10 | -2.23E+10 | -1.19E+10 | -3.00E+11 | -1.26E+11 | -1.04E+11 |

**c) PPML (East Asia dummy)**

| | 1991 | | | 2011 | | |
|---|---|---|---|---|---|---|
| | All | Elec | Trans | All | Elec | Trans |
| | (7) | (8) | (9) | (10) | (11) | (12) |
| Dist | -1.18 *** | -1.28 *** | -1.43 *** | -1.09 *** | -1.37 *** | -1.15 *** |
| | (0.11) | (0.24) | (0.10) | (0.22) | (0.39) | (0.27) |
| GDPi | 1.02 *** | 1.02 *** | 1.35 *** | 1.00 *** | 0.93 *** | 1.13 *** |
| | (0.06) | (0.14) | (0.16) | (0.11) | (0.17) | (0.20) |
| GDPj | 0.84 *** | 0.75 *** | 1.07 *** | 0.95 *** | 0.91 *** | 0.94 *** |
| | (0.12) | (0.16) | (0.13) | (0.08) | (0.08) | (0.16) |
| GDPpcij | -0.09 | 0.46 | -0.29 * | 0.23 | 0.71 *** | -0.14 |
| (i>j) | (0.16) | (0.33) | (0.17) | (0.15) | (0.27) | (0.23) |
| GDPpcij | -0.06 | 0.49 | -0.26 | 0.21 * | 0.65 *** | -0.17 |
| (i<j) | (0.16) | (0.34) | (0.17) | (0.12) | (0.25) | (0.20) |
| E.Asia | 2.21 *** | 2.83 *** | 2.16 *** | 1.64 *** | 2.36 *** | 0.85 |
| | (0.35) | (0.44) | (0.47) | (0.33) | (0.37) | (0.54) |
| Cons. | -20.27 *** | -23.71 *** | -33.42 *** | -26.78 *** | -27.16 *** | -27.34 |
| | (5.41) | (8.79) | (6.33) | (4.23) | (5.11) | (8.67) |
| R2 | 0.971 | 0.901 | 0.974 | 0.819 | 0.864 | 0.732 |
| Pseudo LL | -3.17E+10 | -1.03E+10 | -1.33E+10 | -2.19E+11 | -8.52E+10 | -1.07E+11 |

**d) PPML (East Asia dummy * each North American dummy)**

| | (7) | (8) | (9) | (10) | (11) | (12) |
|---|---|---|---|---|---|---|
| Dist | -1.16 *** | -1.23 *** | -1.45 *** | -1.12 *** | -1.51 *** | -1.16 *** |
| | (0.11) | (0.23) | (0.09) | (0.24) | (0.45) | (0.28) |
| GDPi | 0.93 *** | 0.76 *** | 1.54 *** | 1.03 *** | 1.00 *** | 1.17 *** |
| | (0.11) | (0.29) | (0.17) | (0.21) | (0.36) | (0.25) |
| GDPj | 0.83 *** | 0.74 *** | 1.12 *** | 0.95 *** | 0.91 *** | 0.96 *** |
| | (0.13) | (0.15) | (0.13) | (0.08) | (0.08) | (0.16) |
| GDPpcij | -0.09 | 0.43 | -0.27 | 0.24 | 0.79 *** | -0.14 |
| (i>j) | (0.16) | (0.37) | (0.21) | (0.16) | (0.27) | (0.23) |
| GDPpcij | -0.07 | 0.45 | -0.22 | 0.21 * | 0.68 *** | -0.18 |
| (i<j) | (0.16) | (0.35) | (0.21) | (0.13) | (0.24) | (0.20) |
| E.Asia*USA | 2.32 *** | 3.05 *** | 1.81 *** | 1.62 *** | 2.34 *** | 0.79 |
| | (0.39) | (0.56) | (0.47) | (0.41) | (0.45) | (0.61) |
| E.Asia*MEX | 0.77 ** | 1.10 *** | 0.60 | 2.21 *** | 3.86 *** | 1.02 |
| | (0.36) | (0.39) | (0.52) | (0.72) | (1.44) | (1.00) |
| E.Asia*CAN | 2.06 *** | 2.23 *** | 3.23 *** | 1.44 *** | 2.02 *** | 1.22 ** |
| | (0.30) | (0.32) | (0.38) | (0.30) | (0.62) | (0.59) |
| Cons. | -17.35 *** | -16.12 | -40.23 *** | -27.52 *** | -28.76 *** | -28.87 *** |
| | (6.59) | (13.01) | (7.41) | (6.65) | (10.02) | (9.56) |
| R2 | 0.969 | 0.915 | 0.984 | 0.822 | 0.874 | 0.735 |
| Pseudo LL | -3.01E+10 | -9.38E+09 | -1.17E+10 | -2.15E+11 | -7.82E+10 | -1.07E+11 |

*Notes*: figures in parenthesis ares tandard deviation. *** indicates that the results are statistically significant at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level.

*Data*: authors' calculation.

## Table 10: Gravity Model Estimations for Machinery Imports of North America (Extensive and Intensive Margins): Parts and Components

| | All machinery sectors | | | | Electric machinery sectors | | | | Transport equipment sector | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1991 | | 2011 | | 1991 | | 2011 | | 1991 | | 2011 | |
| | Extensive | Intensive | Extensive | Intensive | Extensive | Intensive | Extensive | Intensive | Extensive | Intensive | Extensive | Intensive |
| **c) PPML (East Asia dummy)** | | | | | | | | | | | | |
| Dist | -0.09 | -1.13 *** | 0.00 | -0.99 *** | -0.13 | -1.38 *** | 0.01 | -1.27 *** | -0.11 | -1.30 *** | 0.03 | -0.98 *** |
| | (0.10) | (0.12) | (0.04) | (0.18) | (0.10) | (0.20) | (0.04) | (0.25) | (0.10) | (0.06) | (0.04) | (0.22) |
| GDPi | 0.31 *** | 0.82 *** | 0.06 *** | 0.61 *** | 0.27 *** | 0.91 *** | 0.03 * | 0.47 *** | 0.33 *** | 0.95 *** | 0.08 *** | 0.78 *** |
| | (0.06) | (0.07) | (0.02) | (0.10) | (0.06) | (0.12) | (0.02) | (0.14) | (0.06) | (0.12) | (0.02) | (0.11) |
| GDPj | 0.47 *** | 0.68 *** | 0.23 *** | 0.63 *** | 0.43 *** | 0.51 *** | 0.18 *** | 0.33 ** | 0.54 *** | 1.06 *** | 0.28 *** | 1.06 *** |
| | (0.03) | (0.10) | (0.01) | (0.11) | (0.04) | (0.14) | (0.01) | (0.14) | (0.04) | (0.08) | (0.02) | (0.12) |
| GDPpcij | -0.03 | 0.04 | -0.04 ** | 0.09 | -0.01 | 0.26 | -0.04 *** | 0.20 | -0.04 | 0.11 | -0.02 | 0.18 |
| (i>j) | (0.04) | (0.14) | (0.02) | (0.13) | (0.05) | (0.31) | (0.01) | (0.18) | (0.04) | (0.14) | (0.02) | (0.23) |
| GDPpcij | 0.02 | 0.05 | -0.02 | 0.09 | 0.03 | 0.30 | -0.03 * | 0.19 | -0.03 | 0.10 | -0.02 | 0.20 |
| (i<j) | (0.04) | (0.13) | (0.02) | (0.13) | (0.04) | (0.30) | (0.02) | (0.18) | (0.04) | (0.13) | (0.02) | (0.20) |
| E.Asia | 0.16 | 1.80 *** | 0.15 *** | 1.65 *** | 0.42 ** | 2.48 *** | 0.21 *** | 2.48 *** | 0.12 | 1.32 *** | 0.04 | 0.91 *** |
| | (0.19) | (0.32) | (0.06) | (0.30) | (0.19) | (0.46) | (0.05) | (0.38) | (0.19) | (0.26) | (0.06) | (0.31) |
| Cons. | -15.13 *** | -17.81 *** | -2.35 *** | -11.63 ** | -13.79 *** | -15.76 ** | -1.13 | 2.18 | -19.84 *** | -30.03 *** | -6.96 *** | -29.14 *** |
| | (2.32) | (4.46) | (0.78) | (4.98) | (2.45) | (7.71) | (0.80) | (6.14) | (2.37) | (4.83) | (0.94) | (5.29) |
| R2 | 0.596 | 0.878 | 0.646 | 0.669 | 0.514 | 0.726 | 0.561 | 0.396 | 0.638 | 0.973 | 0.654 | 0.701 |
| Pseudo LL | -5.54E+03 | -9.35E+07 | -2.40E+03 | -5.77E+08 | -2.46E+03 | -1.46E+08 | -1.21E+03 | -1.13E+09 | -7.20E+02 | -1.46E+08 | -6.22E+02 | -8.74E+08 |
| **d) PPML (East Asia dummy * each North American dummy)** | | | | | | | | | | | | |
| Dist | -0.08 | -1.12 *** | 0.01 | -1.04 *** | -0.12 | -1.35 *** | 0.01 | -1.41 *** | -0.10 | -1.29 *** | 0.03 | -0.99 *** |
| | (0.10) | (0.10) | (0.04) | (0.19) | (0.10) | (0.17) | (0.04) | (0.26) | (0.10) | (0.05) | (0.04) | (0.23) |
| GDPi | 0.30 *** | 0.67 *** | 0.07 *** | 0.62 *** | 0.27 *** | 0.67 *** | 0.03 | 0.54 ** | 0.34 *** | 0.89 *** | 0.09 *** | 0.77 *** |
| | (0.05) | (0.10) | (0.02) | (0.17) | (0.05) | (0.18) | (0.02) | (0.25) | (0.06) | (0.15) | (0.02) | (0.16) |
| GDPj | 0.47 *** | 0.67 *** | 0.23 *** | 0.62 *** | 0.42 *** | 0.50 *** | 0.18 *** | 0.34 *** | 0.54 *** | 1.05 *** | 0.28 *** | 1.05 *** |
| | (0.03) | (0.10) | (0.01) | (0.11) | (0.04) | (0.14) | (0.01) | (0.13) | (0.04) | (0.08) | (0.02) | (0.11) |
| GDPpcij | -0.03 | 0.03 | -0.04 ** | 0.13 | -0.02 | 0.23 | -0.04 *** | 0.30 | -0.04 | 0.11 | -0.03 | 0.18 |
| (i>j) | (0.04) | (0.13) | (0.02) | (0.13) | (0.05) | (0.32) | (0.02) | (0.18) | (0.04) | (0.14) | (0.02) | (0.24) |
| GDPpcij | 0.02 | 0.03 | -0.02 | 0.11 | 0.03 | 0.25 | -0.03 * | 0.24 | -0.03 | 0.10 | -0.02 | 0.21 |
| (i<j) | (0.04) | (0.13) | (0.02) | (0.13) | (0.04) | (0.31) | (0.02) | (0.18) | (0.04) | (0.13) | (0.02) | (0.21) |
| E.Asia*USA | 0.18 | 2.06 *** | 0.13 | 1.65 *** | 0.43 | 2.77 *** | 0.21 ** | 2.40 *** | 0.09 | 1.42 *** | 0.00 | 0.95 ** |
| | (0.33) | (0.39) | (0.09) | (0.34) | (0.32) | (0.57) | (0.08) | (0.42) | (0.30) | (0.34) | (0.10) | (0.46) |
| E.Asia*MEX | -0.04 | -0.26 | 0.09 | 2.42 *** | 0.22 | 0.27 | 0.15 ** | 3.80 *** | 0.01 | -1.07 *** | -0.06 | 1.18 ** |
| | (0.16) | (0.25) | (0.06) | (0.59) | (0.19) | (0.29) | (0.07) | (0.87) | (0.21) | (0.32) | (0.07) | (0.49) |
| E.Asia*CAN | 0.28 | 1.25 *** | 0.25 *** | 0.65 * | 0.56 * | 1.57 *** | 0.29 *** | 1.21 ** | 0.26 | 1.43 *** | 0.18 * | 0.53 |
| | (0.27) | (0.24) | (0.08) | (0.35) | (0.28) | (0.33) | (0.08) | (0.55) | (0.25) | (0.26) | (0.10) | (0.40) |
| Cons. | -14.92 *** | -13.06 ** | -2.43 *** | -11.74 ** | -13.61 *** | -8.44 | -1.11 | -0.15 | -19.93 *** | -28.37 *** | -7.10 *** | -28.46 *** |
| | (2.11) | (5.44) | (0.82) | (5.81) | (2.21) | (10.07) | (0.87) | (7.41) | (2.22) | (5.81) | (0.99) | (5.88) |
| R2 | 0.591 | 0.901 | 0.651 | 0.694 | 0.510 | 0.759 | 0.565 | 0.491 | 0.640 | 0.975 | 0.661 | 0.716 |
| Pseudo LL | -5.51E+03 | -8.49E+07 | -2.38E+03 | -5.22E+08 | -2.45E+03 | -1.33E+08 | -1.21E+03 | -9.59E+08 | -7.19E+02 | -1.39E+08 | -6.18E+02 | -8.47E+08 |

*Notes*: figures in parenthesis ares tandard deviation. *** indicates that the results are statistically significant at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level.

*Data*: authors' calculation.

## Table 11: Gravity Model Estimations for Machinery Imports of North America (Extensive and Intensive Margins): Final Products

| | All machinery sectors | | | | Electric machinery sectors | | | | Transport equipment sector | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1991 | | 2011 | | 1991 | | 2011 | | 1991 | | 2011 | |
| | Extensive | Intensive | Extensive | Intensive | Extensive | Intensive | Extensive | Intensive | Extensive | Intensive | Extensive | Intensive |
| **c) PPML (East Asia dummy)** | | | | | | | | | | | | |
| Dist | -0.11 | -1.13 *** | -0.08 | -1.05 *** | -0.16 | -1.22 *** | -0.04 | -1.33 *** | -0.32 *** | -1.07 *** | -0.15 ** | -1.02 *** |
| | (0.11) | (0.10) | (0.05) | (0.20) | (0.10) | (0.22) | (0.04) | (0.37) | (0.11) | (0.13) | (0.08) | (0.21) |
| GDPi | 0.31 *** | 0.81 *** | 0.12 *** | 0.89 *** | 0.26 *** | 0.90 *** | 0.08 *** | 0.90 *** | 0.37 *** | 0.92 *** | 0.20 *** | 0.97 *** |
| | (0.06) | (0.06) | (0.03) | (0.11) | (0.07) | (0.11) | (0.02) | (0.16) | (0.05) | (0.15) | (0.04) | (0.16) |
| GDPj | 0.54 *** | 0.50 *** | 0.37 *** | 0.70 *** | 0.44 *** | 0.55 *** | 0.26 *** | 0.81 *** | 0.73 *** | 0.86 *** | 0.56 *** | 0.71 *** |
| | (0.04) | (0.10) | (0.02) | (0.06) | (0.04) | (0.12) | (0.02) | (0.07) | (0.04) | (0.11) | (0.03) | (0.11) |
| GDPpcij | -0.05 | -0.07 | -0.06 ** | 0.18 | -0.05 | 0.38 | -0.04 ** | 0.67 *** | -0.01 | -0.14 | -0.07 ** | -0.11 |
| (i>j) | (0.04) | (0.14) | (0.02) | (0.15) | (0.04) | (0.27) | (0.02) | (0.25) | (0.04) | (0.18) | (0.03) | (0.19) |
| GDPpcij | 0.00 | -0.04 | -0.03 | 0.14 | 0.00 | 0.41 | -0.02 | 0.61 *** | -0.01 | -0.13 | -0.05 | -0.17 |
| (i<j) | (0.03) | (0.14) | (0.02) | (0.13) | (0.04) | (0.27) | (0.02) | (0.22) | (0.04) | (0.16) | (0.03) | (0.17) |
| E.Asia | 0.18 | 2.50 *** | 0.19 ** | 1.70 *** | 0.62 *** | 2.94 *** | 0.28 *** | 2.36 *** | -0.02 | 1.96 *** | -0.05 | 1.10 ** |
| | (0.21) | (0.32) | (0.08) | (0.28) | (0.19) | (0.39) | (0.07) | (0.35) | (0.18) | (0.36) | (0.12) | (0.47) |
| Cons. | -16.62 *** | -11.65 *** | -6.91 *** | -22.36 *** | -13.71 *** | -19.10 *** | -4.76 *** | -28.17 *** | -24.40 *** | -22.79 *** | -16.18 *** | -21.04 *** |
| | (2.56) | (3.81) | (1.05) | (3.94) | (2.63) | (6.47) | (0.93) | (4.68) | (2.45) | (5.03) | (1.62) | (6.91) |
| R2 | 0.657 | 0.906 | 0.715 | 0.743 | 0.537 | 0.852 | 0.617 | 0.842 | 0.786 | 0.902 | 0.732 | 0.609 |
| Pseudo LL | -5.96E+03 | -1.07E+08 | -3.54E+03 | -5.17E+08 | -1.89E+03 | -1.08E+08 | -1.12E+03 | -9.03E+08 | -5.09E+02 | -7.17E+08 | -7.15E+02 | -2.76E+09 |
| **d) PPML (East Asia dummy * each North American dummy)** | | | | | | | | | | | | |
| Dist | -0.11 | -1.12 *** | -0.08 | -1.06 *** | -0.15 | -1.19 *** | -0.04 | -1.44 *** | -0.32 *** | -1.08 *** | -0.14 ** | -1.02 *** |
| | (0.11) | (0.10) | (0.05) | (0.22) | (0.10) | (0.20) | (0.04) | (0.42) | (0.11) | (0.12) | (0.07) | (0.22) |
| GDPi | 0.32 *** | 0.66 *** | 0.14 *** | 0.87 *** | 0.27 *** | 0.64 *** | 0.09 *** | 0.93 *** | 0.43 *** | 0.97 *** | 0.23 *** | 0.97 *** |
| | (0.05) | (0.09) | (0.03) | (0.19) | (0.05) | (0.23) | (0.03) | (0.33) | (0.06) | (0.24) | (0.04) | (0.20) |
| GDPj | 0.54 *** | 0.48 *** | 0.37 *** | 0.69 *** | 0.44 *** | 0.54 *** | 0.26 *** | 0.81 *** | 0.70 *** | 0.85 *** | 0.57 *** | 0.71 *** |
| | (0.04) | (0.10) | (0.02) | (0.06) | (0.04) | (0.12) | (0.02) | (0.07) | (0.04) | (0.11) | (0.03) | (0.11) |
| GDPpcij | -0.05 | -0.08 | -0.06 *** | 0.19 | -0.05 | 0.36 | -0.05 ** | 0.73 *** | -0.03 | -0.13 | -0.07 ** | -0.11 |
| (i>j) | (0.04) | (0.13) | (0.02) | (0.16) | (0.04) | (0.29) | (0.02) | (0.25) | (0.04) | (0.19) | (0.03) | (0.19) |
| GDPpcij | 0.00 | -0.06 | -0.03 | 0.15 | 0.00 | 0.39 | -0.02 | 0.63 *** | 0.00 | -0.11 | -0.05 | -0.17 |
| (i<j) | (0.03) | (0.13) | (0.02) | (0.13) | (0.04) | (0.30) | (0.02) | (0.22) | (0.04) | (0.18) | (0.03) | (0.17) |
| E.Asia*USA | 0.12 | 2.70 *** | 0.11 | 1.74 *** | 0.54 | 3.18 *** | 0.22 ** | 2.37 *** | -0.16 | 1.85 *** | -0.27 | 1.11 ** |
| | (0.35) | (0.38) | (0.12) | (0.36) | (0.33) | (0.52) | (0.11) | (0.43) | (0.30) | (0.39) | (0.17) | (0.55) |
| E.Asia*MEX | 0.18 | 0.85 *** | 0.15 | 2.07 *** | 0.57 *** | 1.44 *** | 0.24 *** | 3.65 *** | 0.11 | -0.23 | -0.10 | 1.12 |
| | (0.21) | (0.33) | (0.10) | (0.59) | (0.21) | (0.47) | (0.09) | (1.27) | (0.20) | (0.75) | (0.16) | (0.81) |
| E.Asia*CAN | 0.28 | 2.27 *** | 0.34 *** | 1.25 *** | 0.78 ** | 2.40 *** | 0.40 *** | 1.91 *** | 0.04 | 2.56 *** | 0.27 ** | 1.03 * |
| | (0.30) | (0.30) | (0.11) | (0.27) | (0.31) | (0.31) | (0.11) | (0.53) | (0.21) | (0.55) | (0.14) | (0.55) |
| Cons. | -16.93 *** | -6.91 | -7.30 *** | -21.44 *** | -14.11 | -11.70 | -5.00 *** | -28.52 *** | -25.23 | -24.12 *** | -17.16 *** | -20.85 *** |
| | (2.25) | (5.17) | (1.08) | (6.26) | (2.28) | (10.18) | (0.97) | (9.34) | (2.32) | (7.35) | (1.59) | (7.81) |
| R2 | 0.663 | 0.910 | 0.722 | 0.749 | 0.541 | 0.868 | 0.623 | 0.853 | 0.794 | 0.912 | 0.770 | 0.608 |
| Pseudo LL | -5.95E+03 | -9.82E+07 | -3.50E+03 | -5.07E+08 | -1.88E+03 | -9.88E+07 | -1.12E+03 | -8.36E+08 | -5.08E+02 | -6.76E+08 | -7.02E+02 | -2.76E+09 |

*Notes*: figures in parenthesis are standard deviation. *** indicates that the results are statistically significant at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level.

*Data*: authors' calculation.

Second, the link of North America with East Asia is strong, and the connection of Mexico with East Asia in particular becomes much tighter than other North American countries (the US and Canada) in the electric machinery sector. The coefficient for East Asia is positive and statistically significant (equations c in Tables 8 and 9). In addition, the coefficient is much greater for the electric machinery sector than the transport equipment sector when the results in the same years are compared. Moreover, the coefficient for the interaction term of East Asia with Mexico became positive with statistical significance not only for the total value (equations d-2 and d-5 in Table 8) but also for both extensive and intensive margins (equations d in Table 10) in the case of electric machinery parts and components. Furthermore, the coefficient for the interaction term of East Asia with Mexico became larger than that for the corresponding term with the US or Canada for both electric parts and components and components and final products (equation d-5 in Tables 8 and 9). With controlling distance and other economic conditions, these results suggest that North America, particularly Mexico's connection with East Asia, became stronger than the average predicted by the model, which is particularly true for the electric machinery sector, by the expansion of both intensive and extensive margins.

Third, imports from East Asia by North America are greater than the average predicted by the model in terms of both the import value per product (intensive margin) and the number of imported products (extensive margin) in the electric machinery sector for both parts and components and final products, while they are larger in terms of the intensive margin only for both in the transport equipment sector (equations c in Tables 10 and 11). It implies that North American imports from East Asia grow not only as the results of an expansion of the trade value per product but also as the results of an increase in the number of variety in the electric machinery sector, unlike the case of transport equipment sector where only the intensive margin seem to contribute to an increase in imports. As mentioned in the previous section, such a sectoral difference probably reflects the nature of the sector; the transport equipment sector requires industrial clusters nearby as well as higher transport costs, while parts and components in the electric machinery sector, for instance, are in general smaller and lighter and thus are relatively easy to be transported between countries in long distance.

Regarding control variables other than distance, the coefficients for GDP in exporting country and importing country are positive and statistically significant in most estimations. However, such a tendency seems to become weaker since these coefficients are smaller for 2011 than for 1991. Regarding the difference in GDP per capita, the results are mixed; some are positive and statistically significant while others are not. In particular, equations in 2011 have no statistical results any more for income gap (Table 8). As discussed in subsection 4.1, the difference in factor endowments at the macro level may not sufficiently capture the overall trade pattern with fragmentation of production.

## 5. Summary and The Implication for Economic Integration

This paper investigated developing patterns of machinery trade in North America to analyze the extent and depth of production networks in North America with a link to East Asia. Our descriptive analysis based on the total value of trade and the extensive margin clearly demonstrated the expanding fragmentation of production in North America with a stronger connection of Mexico, in addition to the US, with East Asia on the import side. The extent and depth of production networks in North America grew from the expanding production sharing based on the US-Mexico nexus to the one in the Trans-Pacific with a stronger connection with East Asia of Mexico in addition to the US, particularly in the electric machinery sector. Our quantitative analysis not only on the total value of trade but also extensive and intensive margins also verified the existence of such a strong connection with East Asia for machinery imports in North America, where Mexico enhanced a role of bridging between East Asia and the US. These evidences partially reflect the reduction in services link costs, the evolution of production sharing in the US-Mexico nexus due to various measures that promote activities of MNEs in Mexico such as the Maquiladora, PROSEC (The Program of Sectoral Promotion), and NAFTA, and the strengthening competitiveness for production networks in East Asia in machinery sectors. Behind that, the US firms with operations in East Asia and the East Asian firms (say, Japanese and Korean firms) with operations in Mexico should have significantly contributed to the strengthening connection of Mexico with East Asia as a bridge between the US and East Asia.

As Baldwin (2011) claims, the 2nd unbundling requires a new international policy environment beyond simple tariff removal. Service link costs contain various aspects of transaction costs in international production networks. One of the major components is physical transport cost for materials, parts and components, and final products. In the 1st unbundling, monetary transport cost primarily matters. For the 2nd unbundling, not only monetary transport cost but also time cost as well as the reliability of logistics links is going to be crucial. Therefore, policies supporting international transactions expand from relatively simplistic tariff removal to the removal of non-tariff barriers (NTBs), trade facilitation including customs clearance, logistics and related services liberalization, physical and institutional logistics infrastructure development, and others. Service link costs also include coordination costs; thus, the convergence or harmonization of economic institutions also gains importance. Furthermore, beyond service link costs, newly developed economies and less developed countries typically need to improve their location advantages to invite production blocks; services and investment liberalization, provision of economic infrastructure services such as electricity supply, reform in government procurement, the improvement of intellectual property right protection and competition policy, and the overall betterment of business environment are going to be at issue.

While the World Trade Organization (WTO) has unfortunately lost momentum for expanding its coverage of policy modes at least in the short run, free trade agreements (FTAs) can be an innovative tool for improving international policy environment for the 2$^{nd}$ unbundling. Even in FTAs, tariff removal is still at the center of the effort toward trade liberalization, and the coverage of tariff removal is still one of the important indicators for measuring the quality of FTAs. The utilization of FTA preferential tariffs is not automatic; to capture the fruit of tariff reduction/removal, rules of origin (ROOs) should be user-friendly, and compliance cost including the cost of obtaining certificate of origin must be low. Beyond tariffs, FTAs can enjoy ample flexibility in setting the scope of policy modes. Typical high-level FTAs cover NTBs, services liberalization, investment liberalization, government procurement, intellectual property right protection, competition policy, environment, labor, and even economic cooperation. Actually, in the conclusion of FTA between Japan and Mexico, not only tariff reduction but also activities of business environment council that was established under the FTA has greatly contributed to the expansion of trade and FDI as well as the improvement of business environment (Ando, 2007).

Trans-Pacific Strategic Economic Partnership Agreement (TPP) is currently under negotiation (as of October 2013) and attracts a lot of attention in both academic and journalistic contexts. Although details of the negotiation have not been disclosed, it is announced to target a high level of liberalization as well as international rule making as a mega FTA. The intention of the US delegation may not primarily focus on policy environment for the 2$^{nd}$ unbundling in the manufacturing sector. However, once concluded, TPP seems to work for constructing a better policy environment for international production networks. In particular, TPP may achieve a high coverage of tariff removal, at least vis-à-vis the East Asian standard; services and investment liberalization; government procurement; intellectual property rights protection; competition policy; and dispute settlement. The current set of negotiating countries does not cover the whole Trans-Pacific production networks. However, we may observe a further domino effect as having additional participants in the near future. Even without it, TPP negotiation has already provided good stimulus on negotiations over other FTAs, which include Regional Comprehensive Economic Partnership (RCEP) covering ASEAN+6, China-Japan-Korea FTA, and Japan-EU FTA. If TPP became more likely to be concluded, other FTA negotiations would surely accelerate the process, and the quality of their conclusions would get better. Competition over international rule making among mega FTAs might also work in a benevolent direction.

As for production networks in machinery industries, direct effects of TPP may or may not be significant. For electronics industry, tariffs have been mostly removed by the

Information Technology Agreement (ITA) initiative as well as China's WTO accession, rather than trade liberalization under regionalism, and thus effects of further tariff removal by TPP would be limited. However, international rule making may accelerate the improvement of location advantages for production networks, particularly in newly developed economies and less developed countries currently not participating in TPP negotiation. For automobile industry, there still exist high MFN tariffs as well as possible NTBs, and thus FTAs in general have good potential for obtaining tangible economic gains. However, weak attitude of the US toward automobile industry liberalization is big concern in TPP. Tariff removals under TPP seem to end up with being incomplete or at least delayed. Furthermore, there is some concern on possible acceptance of uncommon tariff concession schedules and business-unfriendly ROOs with ineffective cumulative rule, all of which would particularly serious in automobile industry. Regionalization of production networks in Automobile industry may rather be accelerated due to TPP.

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## APPENDIX

### Table A.1.: The Rankings of Importing Partners and Their Shares in Trade with The World by Each North American Country

### i) Machinery Goods including Both Parts and Components and Final Products

| | All machinery sectors | | | | | | Electric machinery sector | | | | | | Transport equipment sector | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | USA | | Mexico | | Canada | | USA | | Mexico | | Canada | | USA | | Mexico | | Canada | |
| | | % | | % | | % | | % | | % | | % | | % | | % | | % |
| Year: 1991 | | | | | | | | | | | | | | | | | | |
| 1 | JPN | 34.2 | USA | 61.4 | USA | 68.1 | JPN | 32.4 | USA | 55.4 | USA | 59.3 | JPN | 37.7 | USA | 65.3 | USA | 71.7 |
| 2 | CAN | 17.9 | JPN | 7.8 | JPN | 11.8 | MEX | 13.2 | JPN | 11.1 | JPN | 11.7 | CAN | 34.3 | FRA | 13.6 | JPN | 13.8 |
| 3 | DEU | 7.4 | DEU | 7.0 | DEU | 3.3 | CAN | 8.0 | SWE | 5.9 | SPC | 7.0 | DEU | 7.3 | JPN | 4.2 | MEX | 4.1 |
| 4 | MEX | 6.9 | FRA | 4.2 | MEX | 2.8 | KOR | 7.4 | DEU | 5.3 | KOR | 3.0 | MEX | 5.2 | DEU | 3.6 | FRA | 3.0 |
| 5 | Asia | 4.6 | ITA | 2.8 | FRA | 2.1 | Asia | 5.9 | PRK | 3.2 | DEU | 2.8 | GBR | 2.7 | BRA | 3.1 | DEU | 2.9 |
| 6 | GBR | 3.8 | SWE | 2.0 | SPC | 1.7 | MYS | 5.7 | FRA | 3.0 | MEX | 2.5 | FRA | 2.7 | CAN | 2.2 | KOR | 1.0 |
| 7 | SGP | 3.5 | GBR | 1.7 | GBR | 1.6 | SGP | 4.6 | Asia | 1.7 | Asia | 1.9 | SWE | 1.7 | Asia | 2.0 | GBR | 0.9 |
| 8 | KOR | 3.5 | BRA | 1.6 | KOR | 1.5 | CHN | 4.3 | CAN | 1.7 | MYS | 1.6 | KOR | 1.7 | GBR | 1.9 | Asia | 0.5 |
| 9 | FRA | 2.9 | CAN | 1.6 | Asia | 1.3 | DEU | 3.5 | SGP | 1.5 | CHN | 1.5 | ITA | 1.3 | NOR | 0.8 | SWE | 0.4 |
| 10 | MYS | 1.8 | Asia | 1.4 | ITA | 0.8 | HKG | 2.2 | ITA | 1.3 | GBR | 1.4 | Asia | 1.2 | IND | 0.6 | ITA | 0.4 |
| 11 | CHN | 1.7 | CHE | 1.3 | SWE | 0.7 | THA | 2.2 | GBR | 1.3 | FRA | 1.3 | NLD | 0.9 | ESP | 0.6 | BRA | 0.1 |
| 12 | ITA | 1.6 | ESP | 1.3 | SGP | 0.6 | GBR | 2.1 | ESP | 1.2 | SGP | 1.0 | BRA | 0.6 | HKG | 0.4 | CHE | 0.1 |
| 13 | SWE | 1.3 | PRK | 1.2 | CHN | 0.5 | PHL | 1.7 | BRA | 1.1 | HKG | 1.0 | BEL | 0.5 | ITA | 0.4 | SPC | 0.1 |
| 14 | HKG | 1.3 | HKG | 0.6 | CHE | 0.5 | FRA | 1.1 | HKG | 0.9 | CHE | 0.8 | AUS | 0.5 | ARG | 0.2 | THA | 0.1 |
| 15 | CHE | 1.1 | SGP | 0.5 | HKG | 0.4 | ISR | 0.7 | KOR | 0.7 | SWE | 0.6 | ESP | 0.4 | CHN | 0.2 | AUT | 0.1 |
| 16 | THA | 0.9 | NLD | 0.5 | MYS | 0.4 | SWE | 0.7 | PAN | 0.7 | NLD | 0.5 | ISR | 0.3 | GTM | 0.2 | NOR | 0.1 |
| 17 | NLD | 0.9 | BEL | 0.5 | NLD | 0.3 | CHE | 0.6 | NLD | 0.7 | ITA | 0.3 | CHN | 0.2 | BEL | 0.1 | NLD | 0.1 |
| 18 | BRA | 0.7 | PAN | 0.3 | IRL | 0.2 | ITA | 0.6 | CHE | 0.7 | PHL | 0.3 | CHE | 0.1 | NLD | 0.1 | BEL | 0.1 |
| 19 | PHL | 0.6 | KOR | 0.3 | AUT | 0.2 | NLD | 0.5 | BEL | 0.5 | THA | 0.3 | HUN | 0.1 | PAN | 0.1 | CHN | 0.0 |
| 20 | ISR | 0.5 | ARG | 0.3 | THA | 0.2 | IRL | 0.3 | CHN | 0.3 | ESP | 0.2 | SGP | 0.1 | PRK | 0.0 | SGP | 0.0 |
| Year: 2011 | | | | | | | | | | | | | | | | | | |
| 1 | CHN | 24.8 | USA | 37.3 | USA | 51.6 | CHN | 35.3 | CHN | 30.1 | USA | 31.8 | CAN | 24.2 | USA | 56.5 | USA | 65.1 |
| 2 | MEX | 17.0 | CHN | 22.9 | CHN | 12.4 | MEX | 19.5 | USA | 27.4 | CHN | 26.1 | MEX | 20.3 | JPN | 11.4 | MEX | 9.5 |
| 3 | JPN | 11.8 | JPN | 7.4 | MEX | 9.1 | JPN | 6.6 | KOR | 10.0 | MEX | 14.9 | JPN | 19.5 | DEU | 7.0 | JPN | 7.4 |
| 4 | CAN | 9.9 | KOR | 6.1 | JPN | 5.6 | Asia | 6.5 | JPN | 6.0 | Asia | 4.0 | DEU | 11.6 | CAN | 5.7 | DEU | 5.3 |
| 5 | DEU | 7.3 | DEU | 4.9 | DEU | 4.3 | KOR | 5.7 | MYS | 5.4 | JPN | 3.4 | KOR | 5.6 | CHN | 3.6 | KOR | 2.8 |
| 6 | KOR | 4.6 | MYS | 2.9 | KOR | 2.5 | MYS | 4.5 | Asia | 4.7 | KOR | 3.2 | CHN | 4.3 | KOR | 3.5 | CHN | 2.1 |
| 7 | Asia | 3.3 | Asia | 2.5 | GBR | 1.9 | CAN | 2.9 | CRI | 3.1 | DEU | 2.4 | GBR | 2.8 | BRA | 3.0 | GBR | 1.8 |
| 8 | GBR | 2.3 | CAN | 2.1 | Asia | 1.7 | DEU | 2.7 | DEU | 2.3 | MYS | 2.3 | FRA | 2.6 | ESP | 1.7 | FRA | 1.0 |
| 9 | MYS | 2.1 | THA | 1.5 | FRA | 1.1 | CRI | 2.3 | THA | 1.6 | THA | 1.7 | ITA | 1.3 | FRA | 1.0 | ITA | 0.5 |
| 10 | FRA | 2.0 | BRA | 1.4 | ITA | 1.0 | THA | 2.3 | PHL | 1.5 | PHL | 1.2 | Asia | 1.1 | ITA | 1.0 | Asia | 0.5 |
| 11 | ITA | 1.5 | CRI | 1.4 | MYS | 0.8 | PHL | 1.4 | CAN | 1.0 | SGP | 0.8 | ZAF | 1.0 | IND | 0.9 | ZAF | 0.4 |
| 12 | THA | 1.3 | ITA | 1.3 | THA | 0.6 | SGP | 1.1 | SGP | 0.7 | FRA | 0.8 | BEL | 0.7 | ARG | 0.9 | NOR | 0.3 |
| 13 | SGP | 1.1 | ESP | 1.0 | SWE | 0.5 | GBR | 0.9 | ESP | 0.7 | DNK | 0.7 | BRA | 0.6 | GBR | 0.6 | CHE | 0.3 |
| 14 | CHE | 1.1 | PHL | 0.9 | CHE | 0.5 | ITA | 0.7 | FRA | 0.5 | GBR | 0.7 | SWE | 0.6 | Asia | 0.5 | SWE | 0.2 |
| 15 | CRI | 0.9 | FRA | 0.8 | ARE | 0.4 | IDN | 0.7 | IND | 0.5 | SWE | 0.5 | IND | 0.5 | THA | 0.5 | SVK | 0.2 |
| 16 | IRL | 0.7 | SGP | 0.6 | SGP | 0.4 | FRA | 0.6 | BRA | 0.4 | ITA | 0.4 | AUT | 0.4 | SWE | 0.4 | BEL | 0.2 |
| 17 | NLD | 0.7 | GBR | 0.6 | PHL | 0.3 | IND | 0.5 | ITA | 0.4 | ISR | 0.3 | TUR | 0.4 | BEL | 0.3 | TUR | 0.2 |
| 18 | SWE | 0.7 | CHE | 0.5 | DNK | 0.3 | ISR | 0.5 | IDN | 0.4 | IDN | 0.3 | SVK | 0.3 | POL | 0.2 | AUT | 0.1 |
| 19 | PHL | 0.6 | IND | 0.5 | POL | 0.3 | CHE | 0.4 | SWE | 0.4 | CHE | 0.3 | AUS | 0.3 | AUT | 0.2 | FIN | 0.1 |
| 20 | AUT | 0.6 | SWE | 0.4 | AUT | 0.3 | DNK | 0.4 | GBR | 0.3 | IND | 0.3 | ISR | 0.2 | IDN | 0.2 | IND | 0.1 |

*Note*: Asia is "Other Asia, nes", which can be regarded mostly as Taiwan, and SPC is "Special Categories" in the list of UN comtrade.

*Data*: authors' calculation, using data available from UN comtrade.

(Continue)

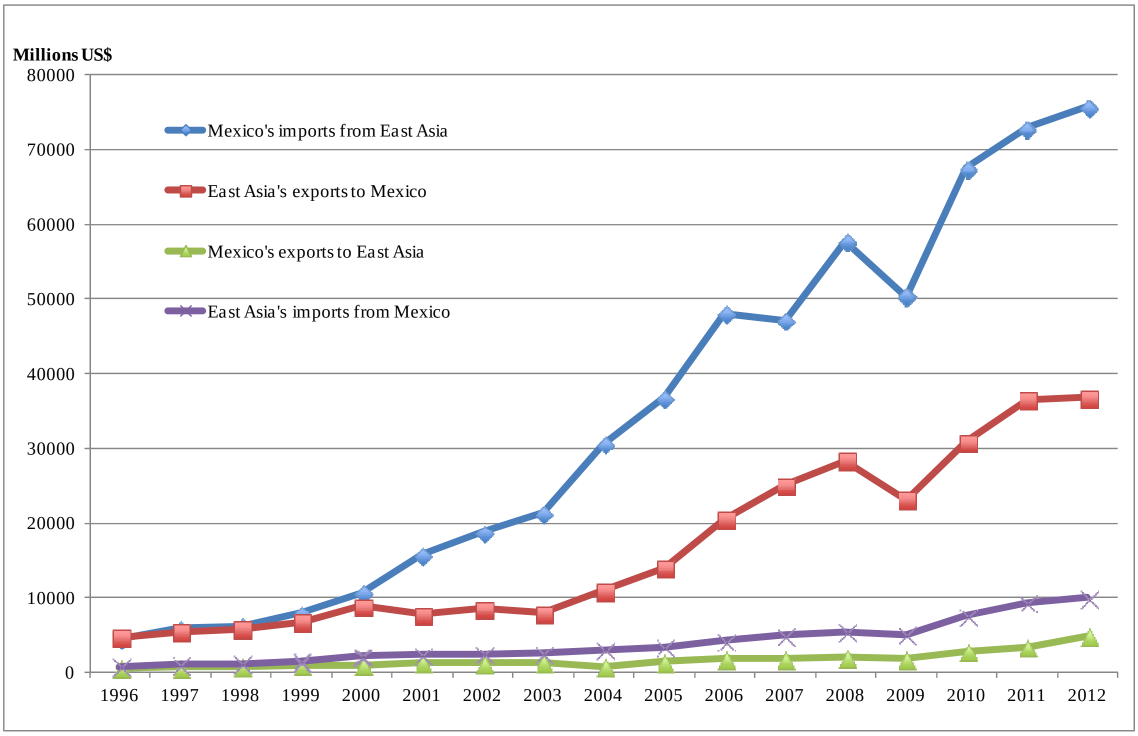
## ii) Machinery Parts and Components

| | All machinery sectors | | | | | | Electric machinery sector | | | | | | Transport equipment sector | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | USA | | Mexico | | Canada | | USA | | Mexico | | Canada | | USA | | Mexico | | Canada | |
| | | % | | % | | % | | % | | % | | % | | % | | % | | % |
| Year: 1991 | | | | | | | | | | | | | | | | | | |
| 1 | JPN | 28.8 | USA | 64.0 | USA | 73.9 | JPN | 27.5 | USA | 55.3 | USA | 64.5 | JPN | 32.3 | USA | 68.2 | USA | 82.3 |
| 2 | CAN | 16.9 | DEU | 6.9 | JPN | 7.0 | MEX | 14.9 | SWE | 11.0 | SPC | 11.0 | CAN | 31.4 | DEU | 7.9 | JPN | 6.1 |
| 3 | MEX | 8.9 | JPN | 6.1 | SPC | 3.3 | CAN | 11.7 | JPN | 8.0 | JPN | 6.7 | MEX | 7.5 | Asia | 4.6 | MEX | 4.2 |
| 4 | DEU | 7.2 | SWE | 3.9 | MEX | 2.9 | KOR | 6.9 | DEU | 6.5 | DEU | 3.7 | GBR | 4.9 | GBR | 4.1 | DEU | 1.5 |
| 5 | GBR | 5.3 | FRA | 3.8 | DEU | 2.9 | Asia | 6.5 | FRA | 3.5 | MEX | 2.6 | FRA | 4.7 | JPN | 3.6 | GBR | 1.4 |
| 6 | Asia | 5.0 | ITA | 2.3 | GBR | 2.0 | MYS | 5.5 | CAN | 2.0 | Asia | 1.6 | ITA | 4.0 | FRA | 2.9 | KOR | 0.9 |
| 7 | FRA | 4.7 | GBR | 2.1 | FRA | 1.3 | SGP | 5.1 | Asia | 1.7 | KOR | 1.4 | DEU | 3.7 | CAN | 2.2 | FRA | 0.9 |
| 8 | SGP | 3.2 | CAN | 1.7 | Asia | 1.0 | DEU | 4.4 | ITA | 1.7 | FRA | 1.3 | Asia | 2.1 | BRA | 1.6 | ITA | 0.5 |
| 9 | KOR | 3.2 | BRA | 1.6 | KOR | 0.9 | PHL | 2.6 | BRA | 1.7 | GBR | 1.3 | ESP | 1.6 | ESP | 1.5 | SWE | 0.5 |
| 10 | ITA | 2.3 | Asia | 1.5 | ITA | 0.8 | GBR | 2.4 | GBR | 1.4 | HKG | 0.9 | BRA | 1.2 | IND | 1.4 | Asia | 0.4 |
| 11 | MYS | 2.1 | ESP | 1.2 | SWE | 0.7 | HKG | 1.9 | ESP | 1.2 | MYS | 0.8 | KOR | 0.9 | ITA | 0.8 | AUT | 0.3 |
| 12 | BRA | 1.2 | CHE | 0.9 | HKG | 0.4 | THA | 1.8 | NLD | 1.1 | SWE | 0.7 | ISL | 0.9 | ARG | 0.6 | SPC | 0.3 |
| 13 | HKG | 1.2 | NLD | 0.6 | AUT | 0.3 | FRA | 1.3 | PRK | 1.0 | SGP | 0.6 | AUS | 0.7 | NLD | 0.1 | NLD | 0.2 |
| 14 | SWE | 1.1 | PRK | 0.5 | NLD | 0.3 | ISL | 0.9 | CHE | 0.7 | CHE | 0.5 | SWE | 0.6 | BEL | 0.1 | BRA | 0.1 |
| 15 | PHL | 1.0 | HKG | 0.4 | SGP | 0.3 | CHN | 0.9 | HKG | 0.7 | PHL | 0.4 | NLD | 0.4 | SGP | 0.1 | ESP | 0.1 |
| 16 | CHE | 1.0 | BEL | 0.4 | CHE | 0.3 | SWE | 0.8 | BEL | 0.5 | NLD | 0.4 | CHE | 0.4 | PRK | 0.1 | BEL | 0.1 |
| 17 | ISL | 0.9 | ARG | 0.3 | CHN | 0.2 | ITA | 0.7 | SGP | 0.4 | ITA | 0.3 | BEL | 0.4 | HKG | 0.0 | IRL | 0.1 |
| 18 | THA | 0.9 | IND | 0.2 | MYS | 0.2 | CHE | 0.6 | PRT | 0.3 | CHN | 0.3 | CHN | 0.4 | CHN | 0.0 | CHE | 0.0 |
| 19 | CHN | 0.8 | SGP | 0.2 | BRA | 0.2 | IRL | 0.4 | KOR | 0.2 | ESP | 0.3 | HUN | 0.3 | IDN | 0.0 | SGP | 0.0 |
| 20 | NLD | 0.7 | DNK | 0.2 | ESP | 0.2 | NLD | 0.4 | MYS | 0.2 | BEL | 0.1 | SGP | 0.3 | VEN | 0.0 | VEN | 0.0 |
| Year: 2011 | | | | | | | | | | | | | | | | | | |
| 1 | CHN | 18.4 | USA | 37.9 | USA | 56.5 | CHN | 21.5 | CHN | 25.8 | USA | 41.8 | MEX | 22.3 | USA | 61.6 | USA | 69.2 |
| 2 | MEX | 16.1 | CHN | 20.8 | CHN | 8.5 | MEX | 18.8 | USA | 25.4 | CHN | 14.0 | JPN | 17.5 | JPN | 11.1 | JPN | 7.4 |
| 3 | JPN | 13.1 | JPN | 8.4 | MEX | 7.4 | JPN | 9.5 | KOR | 13.0 | MEX | 10.8 | CAN | 16.6 | DEU | 6.8 | MEX | 7.4 |
| 4 | CAN | 9.2 | KOR | 7.8 | JPN | 5.5 | MYS | 6.4 | JPN | 7.1 | Asia | 4.8 | CHN | 11.1 | CHN | 4.9 | CHN | 4.6 |
| 5 | DEU | 7.4 | DEU | 4.7 | DEU | 3.3 | Asia | 6.1 | MYS | 6.4 | KOR | 4.4 | DEU | 7.1 | CAN | 4.6 | GBR | 2.9 |
| 6 | KOR | 4.4 | MYS | 3.3 | GBR | 3.0 | CRI | 5.9 | Asia | 4.9 | JPN | 3.8 | KOR | 5.7 | KOR | 2.2 | DEU | 1.6 |
| 7 | Asia | 3.7 | Asia | 2.9 | KOR | 2.2 | KOR | 5.0 | CRI | 4.3 | DEU | 3.1 | GBR | 2.8 | BRA | 1.9 | KOR | 1.2 |
| 8 | GBR | 3.0 | CRI | 2.1 | Asia | 1.9 | DEU | 4.4 | DEU | 2.4 | MYS | 2.4 | Asia | 2.7 | ITA | 1.0 | Asia | 1.0 |
| 9 | FRA | 2.9 | CAN | 1.9 | ITA | 1.3 | CAN | 3.9 | PHL | 2.0 | PHL | 2.3 | FRA | 2.5 | IND | 0.8 | FRA | 0.8 |
| 10 | MYS | 2.9 | BRA | 1.2 | FRA | 1.2 | PHL | 2.6 | THA | 1.6 | THA | 1.5 | ITA | 2.2 | Asia | 0.8 | ITA | 0.6 |
| 11 | ITA | 2.2 | THA | 1.2 | MYS | 0.8 | SGP | 2.1 | CAN | 0.8 | SGP | 1.4 | IND | 1.3 | FRA | 0.7 | IND | 0.2 |
| 12 | CRI | 2.0 | PHL | 1.1 | PHL | 0.6 | THA | 1.5 | SGP | 0.8 | FRA | 1.1 | BRA | 0.8 | ESP | 0.7 | POL | 0.2 |
| 13 | SGP | 1.7 | ITA | 0.9 | POL | 0.6 | GBR | 1.3 | FRA | 0.5 | GBR | 0.8 | AUS | 0.7 | SWE | 0.6 | ESP | 0.2 |
| 14 | IND | 1.0 | FRA | 0.7 | THA | 0.6 | FRA | 1.1 | IND | 0.4 | SWE | 0.6 | ESP | 0.5 | THA | 0.3 | AUT | 0.1 |
| 15 | THA | 1.0 | SGP | 0.5 | SWE | 0.5 | ITA | 1.0 | SWE | 0.4 | CRI | 0.5 | NLD | 0.5 | POL | 0.2 | BRA | 0.1 |
| 16 | PHL | 1.0 | ESP | 0.5 | SGP | 0.5 | IND | 0.7 | ITA | 0.3 | ITA | 0.5 | AUT | 0.5 | AUT | 0.2 | CZE | 0.1 |
| 17 | AUT | 0.9 | IND | 0.5 | IND | 0.3 | ISL | 0.7 | IDN | 0.3 | IND | 0.4 | BEL | 0.5 | CZE | 0.2 | BEL | 0.1 |
| 18 | BRA | 0.8 | GBR | 0.4 | CHE | 0.3 | CHE | 0.6 | ESP | 0.3 | CHE | 0.3 | TUR | 0.4 | TUR | 0.2 | AUS | 0.1 |
| 19 | CHE | 0.8 | SWE | 0.4 | NLD | 0.3 | IDN | 0.6 | CHE | 0.3 | ISL | 0.3 | ISL | 0.4 | GBR | 0.2 | NLD | 0.1 |
| 20 | SWE | 0.7 | CHE | 0.3 | AUT | 0.3 | AUT | 0.4 | CZE | 0.3 | IDN | 0.3 | CZE | 0.4 | ARG | 0.1 | RUS | 0.1 |

*Note*: Asia is "Other Asia, nes", which can be regarded mostly as Taiwan, and SPC is "Special Categories" in the list of UN comtrade.

*Data*: authors' calculation, using data available from UN comtrade.

**Figure A.1.: Mexico's Machinery Trade with East Asia through the US**




*Data source*: UN comtrade.

**Table A.2.: The List of Countries**

| ID | Name | ID | Name | ID | Name |
|---|---|---|---|---|---|
| ARG | Argentina | HUN | Hungary | POL | Poland |
| AUS | Australia | ISL | Iceland | PRT | Portugal |
| AUT | Austria | IDN | Indonesia | ROM | Romania |
| BEL | Belgium | IRL | Ireland | RUS | Russia |
| BRA | Brazil | ISR | Israel | IND | India |
| BGR | Bulgaria | ITA | Italy | SGP | Singapore |
| CAN | Canada | JPN | Japan | SVK | Slovakia |
| CHL | Chile | KOR | Korea | VNM | Viet Nam |
| CHN | China | LUX | Luxembourg | SVN | Slovenia |
| COL | Colombia | MYS | Malaysia | ZAF | South Africa |
| CRI | Costa Rica | MLT | Malta | ESP | Spain |
| CZE | Czech Rep. | MEX | Mexico | SWE | Sweden |
| DNK | Denmark | MAR | Morocco | CHE | Switzerland |
| DOM | Dominican Rep. | NLD | Netherland | THA | Thailand |
| FIN | Finland | NZL | New Zealand | ARE | UAE |
| FRA | France | NIC | Nicaragua | TUN | Tunisia |
| DEU | Germany | NOR | Norway | TUR | Turkey |
| GRC | Greece | PAK | Pakistan | UKR | Ukraine |
| HND | Honduras | PER | Peru | GBR | UK |
| HKG | Hong Kong | PHL | Philippines | USA | USA |

## ENDNOTES

[*] The authors would like to thank Deborah Swenson, Somkiat Tangkitvanich, Jung Sung Chun, Prema-Chandra Athukorala, and other participants in Asian Economic Panel Meeting in Keio University for useful comments.

[1] See, for example, Elms and Low (2013).

[2] The recent value added trade literature includes Mattoo, *et al.* (2013) and Johnson and Noguera (2012a).

[3] More detailed discussion on four layers of transactions is found in Kimura (2010) and ERIA (2010).

[4] In the descriptive argument, we use "electronics" and "automobiles" as industries reflecting typical industry characteristics, while the following data analysis sticks to "electric machinery (HS85)" and "transport equipment (HS86-89)" as clearly defined industry categories.

[5] Athukorala (2011a) claims that production networks are largely regional though final products travel across regions, which is consistent with the findings of this paper.

[6] See Athukorala (2011b) for the importance of a local vendor networks and others in the case of Penang, Malaysia.

[7] Machinery is defined as Harmonized System (HS) 84-92. Machinery parts and components are as follows: 8406, 8407, 8408, 8409, 8410, 8411, 8412, 8413, 8414, 8416, 8417, 8431, 8448, 8466, 8473, 8480, 8481, 8482, 8483, 8484, 8485, 8503, 8505, 8507, 8511, 8512, 8522, 8529, 8531, 8532, 8533, 8534, 8535, 8536, 8537, 8538, 8539, 8540, 8541, 8542, 8544, 8545, 8546, 8547, 8548, 8607, 8706, 8707, 8708, 8714, 8803, 8805, 9001, 9002, 9003, 9013, 9014, 9033, 9104, 9110, 9111, 9112, 9113, 9114, 9209, 840140, 840290, 840390, 840490, 840590, 841590, 841891, 841899, 841990, 842091, 842099, 842123, 842129, 842131, 842191, 842199, 842290, 842390, 842490, 843290, 843390, 843490, 843590, 843691, 843699, 843790, 843890, 843991, 843999, 844090, 844190, 844240, 844250, 844390, 845090, 845190, 845240, 845290, 845390, 845490, 845590, 846791, 846792, 846799, 846890, 847490, 847590, 847690, 847790, 847890, 847990, 850490, 850690, 850890, 850990, 851090, 851390, 851490, 851590, 851690, 851790, 851840, 851850, 851890, 853090, 854390, 870990, 871690, 900590, 900691, 900699, 900791, 900792, 900890, 900990, 901090, 901190, 901290, 901590, 901790, 902490, 902590, 902690, 902790, 902890, 902990, 903090, 903190, 903290 (the version of HS1992 (See Ando and Kimura (2005)). Machinery final products are defined as those other than parts and components.

[8] The paper defines East Asia as the nine East Asian countries (China, Hong Kong, Indonesia, Japan, Korea, Malaysia, the Philippines, Singapore, and Thailand). Although Taiwan is also an important player in production networks in East Asia, the data for this economy is not unfortunately available from the database (UN Comtrade) explicitly as either reporter or partner.

[9] As mentioned in footenote 7, Taiwan is also an important player in production networks in East Asia. The corresponding share of East Asia should be raised if Taiwan is included, though East Asia in this paper does not include it. Considering that "Other Asia" in Table A.1 in the Appendix could be mostly regarded as Taiwan, the portion of East Asia can further rise by up to five to six percent.

[10] Figures 2 and 3 present the number for parts and components or final products. The corresponding figures for the total including both are available upon request.

[11] This is consistent with the finding by Kehoe and Ruhl (2013) where "least traded goods" contribute to the trade expansion between Canada and Mexico for the whole merchandise trade. "Least traded goods" are likely to include newly traded goods presented in Table 6.

[12] Again, consistent with Kehoe and Ruhl (2013), trade between China and the US expands extensive margins. However, changes are even larger for Mexico and Canada than the US.

[13] The equations with the absolute term of the difference in GDP per capita without identifying which country has higher income are also examined. However, the results are similar.

[14] Our definition of measuring extensive and intensive margins follows Flam and Nordstrom (2011) and Hayakawa, *et al.* (2011). There are various definitions of extensive and intensive margins for the analysis, using finely disaggregated bilateral trade at the country level (not bilateral trade data at the firm level). For instance, Haddad, *et al.* (2010) decompose changes in total trade (the percentage change in the total value of trade) into these margins as follows: intensive margins are composed of effects due to changes in quantity and price, and extensive margins consist of an effect due to exiting products (exit effect) and an effect due to new products (entry effect). See also Hummels and Klenow (2005) and Helpman, *et al.* (2008) for the examples of other types of definitions.

[15] Available from http://comtrade.un.org/db/default.aspx.

[16] Available from http://www.cepii.fr/anglaisgraph/bdd/distances.htm. See Mayer and Zignago (2011) for the details on CEPII's distances measures.

[17] Available from http://databank.worldbank.org/ddp/home.do.

[18] Another approach would be the extended technique of the Heckman two-step estimation to take such a systematic sample selection into account; see, for instance, Helpman, *et al.* (2008).

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